भारतीय मानक
Indian Standard

IS 17017 (Part 1) : 2018

विद्युतीय वाहन चालकता चार्जिंग पद्धति

भाग 1 सामान्य अपेक्षायें

Electric Vehicle Conductive Charging System

Part 1 General Requirements

ICS 43.120

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Electrotechnology in Mobility Sectional Committee, ETD 51

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Electrotechnology in Mobility Sectional Committee had been approved by the Electrotechnical Division Council.

This standard provides guidance to industry for setting up charging stations and to the electric vehicle manufactures to prepare the vehicles to charge the batteries, from these charging stations.

Considerable assistance has been obtained from IEC 61851-1 : 2017 while preparing this standard. This standard corresponds to the requirements of IEC 61851-1 : 2017 in the requirements it contains, but certain modifications has been done in relation to the cross referred standards, included content, and ambient conditions.

The cross references of IEC have been modified to refer Indian Standards whenever available. Where corresponding Indian Standards are not available, the IEC references have been retained. The committee has decided that these IEC standards are suitable to be used till equivalent/corresponding Indian Standards are published.

The committee had agreed to inclusion of only with Type 2, and Systems A and C defined in IEC standards, and as such the references to other types and systems have not been retained in this edition. The ambient temperature has been modified, and system voltages aligned as per IS 12360. Committee had also decided not to retain Annexes D and E of IEC 61851-1 : 2017.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding of numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTRIC VEHICLE CONDUCTIVE CHARGING SYSTEM

PART 1 GENERAL REQUIREMENTS

1 SCOPE

1.1 This part of IS 17017 (Part 1) : 2018, applies to electric road vehicle (EV) supply equipment for charging electric road vehicles, with a rated supply voltage up to 1 000 V a.c. or up to 1 500 V d.c. and a rated output voltage up to 1 000 V a.c. or up to 1 500 V d.c.

1.2 Electric road vehicles (EV) cover all road vehicles, including plug-in hybrid road vehicles (PHEV), that derive all or part of their energy from on-board rechargeable energy storage systems (RESS).

1.3 This standard also applies to EV supply equipment supplied from on-site storage systems (for example, buffer batteries).

1.4 The aspects covered in this standard include:

a) The characteristics and operating conditions of the EV supply equipment;
b) The specification of the connection between the EV supply equipment and the EV; and
c) The requirements for electrical safety for the EV supply equipment.

Additional requirements may apply to equipment designed for specific environments or conditions, for example:

a) EV supply equipment located in hazardous areas where flammable gas or vapour and/or combustible materials, fuels or other combustible, or explosive materials are present;
b) EV supply equipment designed to be installed at an altitude of more than 2 000 m; and
c) EV supply equipment intended to be used on board on ships.

1.5 Requirements for electrical devices and components used in EV supply equipment are not included in this standard and are covered by their specific product standards.

1.6 Requirements for bi-directional energy transfer are under consideration and are not presently within the scope of this Standard (Part 1).

1.7 This standard does not apply to:

a) Safety aspects related to maintenance;
b) Charging of trolley buses, rail vehicles, industrial trucks and vehicles designed primarily for use off-road;
c) Equipment on the EV;
d) EMC requirements for equipment on the EV while connected, which are covered in IEC 61851-21-1;
e) Charging RESS off board of the EV; and
f) d.c. EV supply equipment that relies specifically on double/reinforced insulation or class III protection against electric shock (*see* IEC 61851-23 or the future IEC 61851-3 series).

1.8 This standard; series covers all EV supply equipment with the exception of in-cable control and protection devices for Mode 2 charging of electric road vehicles (IC-CPD) which are covered by IEC 62752.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below:

IS No./ Other Publication	*Title*
IS 1293 : 2005	Plugs and socket-outlets of rated voltage up to and including 250 volts and rated current up to 16 amperes
IS 302 (Part 1) : 2008	Safety of household and similar appliances: Part 1 General requirements
IS 732 : 2018	Code of practice for electrical wiring installations. *(under print)*
IS 9000 (Part 2/ Sec 1 to 4) : 1978	Basic environmental testing procedures for electronic and electrical items: Part 2 Cold test

IS No./ Other Publication	*Title*
IS 9000 (Part 3/ Sec 1 to 5) : 1977	Basic environmental testing procedures for electronic and electrical items: Part 3 Dry heat test
IS 9000 (Part 4) : 2008	Basic environmental testing procedures for electronic and electical items: Part 4 Damp heat (steady state)
IS 9000 (Part 5/ Sec 1 and 2) : 1981	Basic environmental testing procedures for electronic and electical items: Part 5 Damp heat (cyclic) test.
IS 13703 (all parts)	Low voltage fuses
IS 15382 (Part 1) : 2014	Insulation coordination for equipment within low-voltage Systems: Part 1 Principles, requirements, and tests
ISO 15118-1 : 2013	Road vehicles — Vehicle to grid communication interface — Part 1: General information and use-case definition
ISO 17409 : 2015	Electrically propelled road vehicles — Connection to an external electric power supply — Safety requirements
IS/IEC 60309-1 : 2002	Plugs, socket-outlets and couplers for industrial purposes: Part 1 General requirements
IS/IEC 60309-2 : 2002	Plugs, socket-outlets and couplers for industrial purposes: Part 2 Dimensional interchangeability requirements for pin and contact-tube accessories
IS 12640 (Part 1) : 2016	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs): Part 1 General rules
IS 12640 (Part 2) : 2016	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs): Part 2 General rules
IS/IEC 61439-1 : 2011	Low-voltage switchgear and controlgear assemblies: Part 1General rules (*under print*)
IEC TS 61439-7 : 2014	Low-voltage switchgear and controlgear assemblies — Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicles charging stations
IS/IEC 61508	(all parts) Functional safety of electrical/electronic/ programmable electronic safety-related systems
IEC 61851-24 : 2014	Electric vehicle conductive charging system — Part 24: Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging
IEC 62335 : 2008	Circuit breakers — Switched protective earth portable residual current devices for class I and battery powered vehicle applications
IEC 62752 : 2016	In cable control and protection device for mode 2 charging of electric road vehicles (IC-CPD)
IEC 62196-1 : 2014	Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 1: General requirements
IEC 62196-2 : 2016	Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 2: Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories
IEC 62196-3 : 2014	Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 3: Dimensional compatibility and interchangeability requirements for d.c. and a.c./d.c. pin and contact-tube vehicle couplers
IS 12360 : 1988	Voltage bands for electrical installations including preferred voltages and frequency
IEC 61851-23 : 2014	Electric vehicle conductive charging system — Part 23: d.c. electric vehicle charging station

IS No./ Other Publication	*Title*
IS 13252 (Part 1) : 2010	Information technology equipment — Safety: Part 1 General requirements
IS/IEC 60529 : 2001	Degrees of protection provided by enclosures (IP Code)
IS/IEC 60898-1 : 2015	Electrical accessories — Circuit-breakers for overcurrent protection for household and similar installations: Part 1 Circuit-breakers for a.c. operation
IS/IEC 60898-2 : 2003	Electrical accessories — Circuit-breakers for overcurrent protection for household and similar installations: Part 2 Circuit-breakers for a.c. and d.c. operation
IS/IEC 60947-2 : 2016	Low-voltage switchgear and controlgear: Part 2 Circuit-breakers
IS/IEC 60947-3 : 2012	Low-voltage switchgear and controlgear: Part 3 Switches, disconnectors, switch-disconnectors and fuse-combination units
IS/IEC 60947-4-1 : 2012	Low voltage switchgear and controlgear: Part 4-1 Contactors and motor-starters — Electromechanical contactors and motor-starters
IEC 61316 : 1999	Industrial cable reels
IS/IEC 61558-1 : 1997	Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests
IEC 61558-2-4 : 2009	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V — Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers
IS/IEC 60947-6-2 : 2007	Low-voltage switchgear and controlgear — Part 6-2: Multiple function equipment — Control and protective switching devices (or equipment) (CPS) *(under print)*
IS/IEC 60990 : 2016	Methods of measurement of touch current and protective conductor current
IEC 61180 : 2016	High-voltage test techniques for low-voltage equipment — Definitions, test and procedure requirements, test equipment
IS/IEC 61810-1 : 2015	Electromechanical elementary relays: Part 1 General and safety requirements *(under print)*
IEC 62262 : 2002	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

3 TERMS AND DEFINITIONS

For the purposes of this document, the following terms and definitions shall apply.

3.1 Electric Supply Equipment

3.1.1 *EV Supply Equipment*

Equipment or a combination of equipment, providing dedicated functions to supply electric energy from a fixed electrical installation or supply network to an EV for the purpose of charging.

Examples:

1. For Mode 3 Case B, the EV supply equipment consists of the charging station and the cable assembly.
2. For Mode 3 Case C, the EV supply equipment consists of the charging station with its cable assembly.

3.1.2 *a.c. EV Supply Equipment*

EV supply equipment that supplies alternating current to an EV.

3.1.3 *d.c. EV Supply Equipment*

EV supply equipment that supplies direct current to an EV.

3.1.4 *EV Charging System*

Complete system including the EV supply equipment and the EV functions that are required to supply electric energy to an EV for the purpose of charging.

3.1.5 *EV Charging Station*

Stationary part of EV supply equipment connected to the supply network

NOTE — For Case C, the cable assembly is part of the EV charging station.

3.1.6 *d.c. EV Charging Station*

EV charging stations that supplies direct current to an EV.

3.1.7 *a.c. EV Charging Station*

EV charging station that supplies alternating current to an EV.

3.1.8 *Charging*

All functions necessary to condition voltage and/or current provided by the a.c. or d.c. supply network to assure the supply of electric energy to the RESS

3.1.9 *Charging Mode*

Method for connection of an EV to the supply network to supply energy to the vehicle.

NOTE — Mode 1, Mode 2, Mode 3 and Mode 4 are described in **6**.

3.1.10 *Case A*

Connection of an EV to the supply network with a plug and cable permanently attached to the EV (*see* Fig. 1).

NOTE — The cable assembly is part of the vehicle.

3.1.11 *Case B*

Connection of an EV to a supply network with a cable assembly detachable at both ends (*see* Fig. 2).

NOTE — The detachable cable assembly is not part of the vehicle or the charging station.

3.1.12 *Case C*

Connection of an EV to a supply network utilizing a cable and vehicle connector permanently attached to the EV charging station (*see* Fig. 3).

NOTE — The cable assembly is part of the EV charging station.

3.2 Insulation

3.2.1 *Basic Insulation*

Insulation of hazardous-live-parts which provides basic protection.

3.2.2 *Direct Contact*

Electrical contact of persons or animals with live parts.

3.2.3 *Double Insulation*

Insulation comprising both basic insulation and supplementary insulation.

3.2.4 *Conductive Part*

Part which can carry electric current.

3.2.5 *Exposed Conductive Part*

Conductive part of electrical equipment, which can be touched and which is not normally live, but which can become live when basic insulation fails.

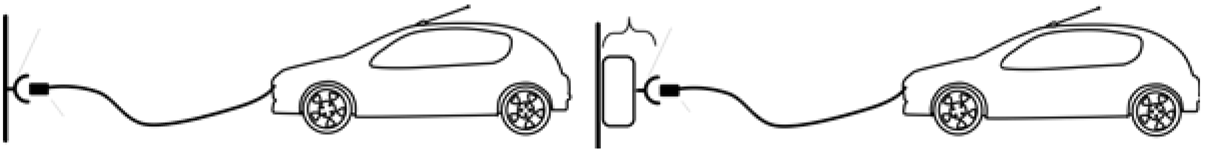


Fig. 1 Case A Conection

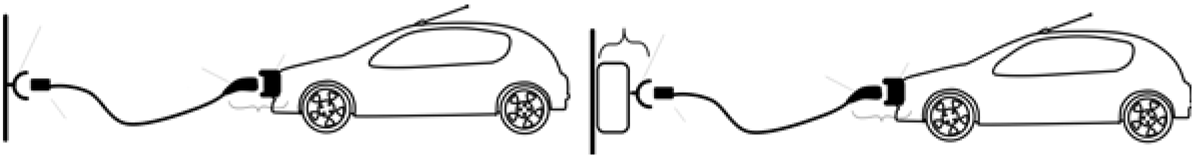


Fig. 2 Case B Connection

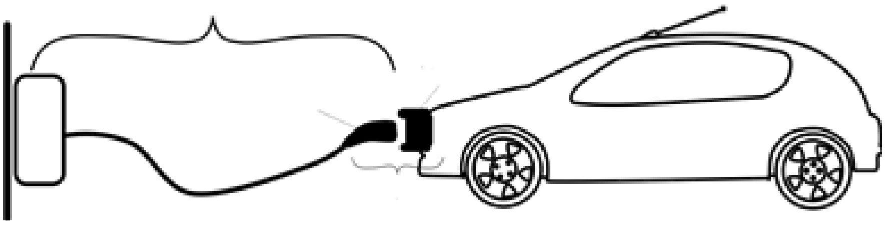


Fig. 3 Case C Connection

Key for Figures 1 to 3	
(a) Socket-outlet	(f) Vehicle inlet
(b) Plug	(g) Charging station
(c) Cable	(h) EV socket-outlet
(d) Vehicle connector	(i) EV plug
(e) Vehicle coupler	

NOTE — A conductive part of electrical equipment which can only become live through contact with an exposed-conductive-part which has become live is not considered to be an exposed-conductive-part itself.

3.2.6 *Hazardous-Live-Part*

Live part which, under certain conditions, can give a harmful electric shock.

3.2.7 *Fault Protection*

Protection against shock under single-fault conditions.

3.2.8 *Insulation*

All the materials and parts used to insulate conductive elements of a device, or a set of properties which characterize the ability of insulation to provide its function.

3.2.9 *Live Part*

Conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN (*see* 3.138 of IS 732) conductor or PEM (*see* 3.137 of IS 732) conductor or PEL (*see* 3.135 of IS 732) conductor

NOTE — This concept does not necessarily imply a risk of electric shock.

3.2.10 *Reinforced Insulation*

Insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation.

NOTE — Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation.

3.2.11 *Supplementary Insulation*

Independent insulation applied in addition to basic insulation for fault protection.

3.3 Functions

3.3.1 *Control Pilot Conductor*

Insulated conductor incorporated in a cable assembly, which, together with the protective conductor, is part of the control pilot circuit.

3.3.2 *Control Pilot Circuit*

Circuit designed for the transmission of signals or communication between the EV and the EV supply equipment.

NOTE — for Mode 2 it is between the EV and the ICCB (*see* **3.5.5**) or IC-CPD (*see* **3.5.6**).

3.3.3 *Control Pilot Function*

Function used to monitor and control the interaction between the EV and the EV supply equipment.

3.3.4 *Control Pilot Function Controller(CPFC)*

Device in the EV supply equipment and the EV responsible for the control pilot function and the generation of the PWM signal.

3.3.5 *Proximity Function*

Electrical or mechanical means to indicate the insertion state of the vehicle connector in the vehicle inlet to the EV and/or to indicate the insertion state of the plug in the socket-outlet of the EV charging station

3.4 Vehicle

3.4.1 *Electric Vehicle (EV) (Electric Road Vehicle)*

Any vehicle propelled by an electric motor drawing current from an RESS, intended primarily for use on public roads.

NOTE — In this standard, these terms refer only to those vehicles that can be charged from an external electrical source.

3.4.2 *Plug in Hybrid Electric Road Vehicle (PHEV)*

Electrical vehicle that can charge the rechargeable electrical energy storage device from an external electric source and also derives part of its energy from another on-board source.

3.4.3 *Rechargeable Energy Storage System (RESS)*

System that stores energy for delivery of electric energy and which is rechargeable.

3.5 Cords, Cables and Connection Means

3.5.1 *Adaptor*

Portable accessory constructed as an integral unit incorporating both a plug portion and one socket-outlet portion.

3.5.2 *Cable Assembly*

Assembly consisting of flexible cable or cord fitted with a plug and/or a vehicle connector, that is used to establish the connection between the EV and the supply network or an EV charging station

NOTES

1 A cable assembly can be detachable or be a part of the EV or the EV charging station.

2 A cable assembly can include one or more cables, with or without a fixed jacket, which can be in a flexible tube, conduit or wire way.

3.5.3 *Cable Management System*

One or more devices that is intended to protect a cable assembly from mechanical damage and/or to facilitate its handling.

Example:

Cable suspension device.

3.5.4 *Cord Extension Set*

Assembly consisting of a flexible cable or cord fitted with plug and a portable socket-outlet or connector which can match each other.

NOTES

1 The cord is called an “adapter cord” when the plug and socket-outlet do not match.

2 A Mode 1, Mode 2 or Mode 3 cable assembly is not considered as a cord extension set.

3.5.5 *In-Cable Control Box (ICCB)*

Device incorporated in the Mode 2 cable assembly, which performs control functions and safety functions

NOTE — The "ICCB" is called "function box" in IEC 62752.

3.5.6 *IC-CPD*

Mode 2 cable assembly that complies with IEC 62752.

3.5.7 *EV Socket-Outlet*

Specific socket-outlet intended to be used as part of EV supply equipment and defined in the IEC 62196 series.

3.5.8 *EV Plug*

Specific plug intended to be used as part of EV supply equipment and defined in the IEC 62196 series.

3.5.9 *Plug*

Accessory having pins designed to engage with the contacts of a socket-outlet, also incorporating means for the electrical connection and mechanical retention of flexible cables or cords.

3.5.10 *Socket-Outlet*

Accessory having socket-contacts designed to engage with the pins of a plug and having terminals for the connection of cables or cords.

3.5.11 *Standard Plug and Socket-Outlet*

Plug and socket-outlet which meets the requirements of interchangeability as defined in relevant Indian standards on plugs and socket outlets, excluding the specific EV accessories as defined in the IEC 62196 series.

NOTE — The IS/IEC 60309-1, IS/IEC 60309-2 and IS 1293 define standard plugs and socket-outlets.

3.5.12 *Vehicle Coupler (Electric Vehicle Coupler)*

Means of enabling the connection at will of a flexible cable to an electric vehicle.

NOTE — It consists of two parts, a vehicle connector and, a vehicle inlet.

3.5.13 *Vehicle Connector (Electric Vehicle Connector)*

Part of a vehicle coupler integral with, or intended to be attached to the cable assembly.

3.5.14 *Vehicle Inlet (Electric Vehicle Inlet)*

Part of a vehicle coupler incorporated in, or fixed to, the electric vehicle.

3.5.15 *Connecting Point*

Point where one electric vehicle is connected to the fixed installation.

NOTES

1 The connecting point for Modes 1 and 2 is the point where one electric vehicle is connected to the fixed installation or supply network.

2 The connecting point for Modes 3 and 4 is the point where one electric vehicle is connected to the EV charging station.

3 The connecting point for Mode 1, Mode 2 and Mode 4, connected by a cable and plug is the standard socket-outlet.

4 The connecting point for Mode 3 and permanently connected Mode 4 is the EV socket-outlet (Case A and Case B) or the EV connector (Case C).

3.5.16 *Interlock*

Device or combination of devices that prevents the power contacts of a socket-outlet/vehicle connector from becoming live before it is in proper engagement with a plug/vehicle inlet, and which either prevents the plug/vehicle connector from being withdrawn while its power contacts are live or makes the power contacts dead before separation.

3.5.17 *Retaining Means*

Device (for example, mechanical or electromechanical) that holds a plug or vehicle connector in position when it is in proper engagement, and prevents its unintentional withdrawal.

3.5.18 *Latching Device*

Part of the interlock mechanism provided to hold a plug in the socket-outlet or vehicle connector in the vehicle inlet to prevent its intentional or unintentional withdrawal.

3.5.19 *Locking Mechanism*

Means intended to reduce the likelihood of tampering with, or an unauthorised removal, of the accessories.

3.5.20 *Vehicle Adaptor*

Portable accessories constructed as an integral unit incorporating both vehicle inlet portion and vehicle connector portion.

3.6 Service and Usage

3.6.1 *Indoor Use*

Intended for operation under normal ambient conditions in a building.

3.6.2 *Outdoor Use*

Capable of operating under specific range of outdoor conditions.

3.6.3 *Equipment for Locations with Restricted Access*

Equipment accessible to all persons who are authorized to have access to the location (for example, equipment located in private housing, private parking areas or similar places).

3.6.4 *Equipment for Locations with Non-Restricted Access*

Equipment accessible for all persons, for example, access available in a public area.

3.6.5 *Portable Equipment*

Cord and plug connected equipment, cable assembly, adaptors or other accessories that are capable to be carried by one person and designed and intended to be carried within the EV.

3.6.6 *Mobile Equipment*

Electric equipment which is moved while in operation or which can easily be moved from one place to another while connected to the supply.

3.6.7 *Stationary Equipment*

Equipment or electric equipment not provided with a carrying handle and having such a mass that it cannot easily be moved.

NOTE — Stationary equipment is intended to be either permanently connected to the supply network or connected to the supply network by a cable and plug.

3.6.8 *Ground Mounted*

Equipment with a part intended to be embedded or attached to the ground.

3.6.9 *Permanently Connected EV Supply Equipment*

EV supply equipment that can only be connected to, or disconnected from, the a.c. or d.c. supply network by the use of a tool.

3.6.10 *User*

Party who will specify, purchase, use and/or operate the EV supply equipment, or someone acting on their behalf.

3.7 General Terms

3.7.1 *Supply Network*

Any source of electric energy (for example, mains or electric grid, distributed energy resources (DER), battery bank, PV installation, generator, etc.).

3.7.2 *Protective Conductor*

Conductor provided for purposes of safety, for example protection against electric shock.

Example:

Protective conductor includes a protective bonding conductor, protective earthing conductor and an earthing conductor when used for protection against electric shock.

3.7.3 *Protective Earthing Conductor*

Protective conductor provided for protective earthing.

3.7.4 *Earthing Terminal*

Terminal provided on equipment or on a device and intended for the electric connection with the earthing arrangement.

3.7.5 *Protective Earthing*

Earthing a point or points in a system or in an installation or in equipment for purposes of electrical safety.

3.7.6 *Residual Current Device (RCD)*

Mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions.

NOTE — A residual current device can be a combination of various separate elements designed to detect and evaluate the residual current and to make and break current.

3.7.7 *Leakage Current*

Electric current in an unwanted conductive path under normal operating conditions.

3.7.8 *Switching Device*

Device designed to make or break the current in one or more electric circuits.

3.7.9 *Mechanical Switching Device*

Switching device designed to close and open one or more electric circuits by means of separable contacts.

3.7.10 *Touch Current*

Electric current passing through a human body or through an animal body, when it touches one or more accessible parts of an electrical installation or electrical equipment.

4 GENERAL REQUIREMENTS

The EV supply equipment shall be so constructed that an EV can be connected to the EV supply equipment so that in normal conditions of use, the energy transfer operates safely, and its performance is reliable and minimises the risk of danger to the user or surroundings.

Compliance is checked by meeting all of the relevant requirements of the IS 17017 series.

4.1 Unless otherwise stated all tests indicated in this standard are type tests.

4.2 Unless otherwise stated, all tests required by this standard may be conducted on separate samples or on the same sample as per the mutual agreement between the user and the manufacturer

4.3 Unless otherwise stated, each test is conducted once.

4.4 Unless otherwise specified, all tests shall be carried out in a draught-free location at an ambient temperature of 27° ± 2°C and at a relative humidity of 65 ± 5 percent.

4.5 The EV supply equipment shall be rated for one or more of standard nominal voltages and frequencies as given in IS 12360.

4.6 Assemblies for EV supply equipment shall comply with IEC TS 61439-7 with the exceptions or additions as indicated in **13**.

4.7 The standard applies to equipment that is designed to be used at an altitude up to 2 000 m.

4.8 For equipment designed to be used at altitudes above 2 000 m, it is necessary to take into account the reduction of the dielectric strength and the cooling effect of the air. Electrical equipment intended to operate under these conditions shall be designed or used in accordance with an agreement between manufacturer and user.

5 CLASSIFICATION

5.1 Characteristics of Power Supply and Output

5.1.1 *Characteristics of Pwer Supply Input*

The EV supply equipment shall be classified according to the supply network system that it is intended to be connected to:

a) EV supply equipment connected to a.c. supply network; and
b) EV supply equipment connected to d.c. supply network.

The EV supply equipment shall be classified according to the electric connection method:

a) Plug and cable connected; and
b) Permanently connected.

5.1.2 *Characteristics of Power Supply Output*

The EV supply equipment shall be classified according to the type of current the EV supply equipment delivers:

a) a.c. EV supply equipment;
b) d.c. EV supply equipment; and
c) a.c. and/or d.c. EV supply equipment.

5.2 Normal Environmental Conditions

The EV supply equipment shall be classified according to the environmental conditions and use:

a) Indoor use; and
b) Outdoor use.

NOTE — The conditions that define indoor and outdoor use are given in **7.1.1** of IS/IEC 61439-1 (*under print*).

5.3 Special Environmental Conditions

The EV supply equipment may be classified according to their suitability for use in special environmental conditions other than those specified in this document, if declared so by the manufacturer.

5.4 Access

The EV supply equipment shall be classified according to the location they are intended for:

a) Equipment for locations with restricted access; and
b) Equipment for locations with non-restricted access.

5.5 Mounting Method

The EV supply equipment shall be classified according to the type of mounting:

a) Stationary equipment;
    1) Mounted on walls, poles or equivalent positions:
        i) Flush mounted; and
        ii) Surface mounted.
    2) Pole/column/pipe-mounted;
    3) Floor mounted; and
    4) Ground mounted.
b) Non stationary equipment:
    1) portable equipment; and
    2) mobile equipment.

NOTE — More than one classification can apply.

5.6 Protection Against Electric Shock

The equipment shall be classified according to the protection against electric shock:

a) Class I equipment;
b) Class II equipment; and
c) Class III equipment.

NOTE — Class I, Class II and Class III descriptions can be found in IS 302 (Part 1).

5.7 Charging Modes

The EV supply equipment shall be classified according to **6.2**:

a) Mode 1;
b) Mode 2;
c) Mode 3; and
d) Mode 4.

NOTE — EV supply equipment with multiple outputs can be classified as supporting more than one mode.

6 CHARGING MODES AND FUNCTIONS

6.1 General

Clause **6** describes the different charging modes and functions for energy transfer to EVs.

6.2 Charging Modes

6.2.1 *Mode 1*

Mode 1 is a method for the connection of an EV to a standard socket-outlet of an a.c. supply network, utilizing a cable and plug, both of which are not fitted with any supplementary pilot or auxiliary contacts.

The rated values for current and voltage shall be as follows:

	Single Phase a.c.	Three Phase a.c.
Rated Voltage	240 V	415 V
Maximum rated current	16 A	16 A

EV supply equipment intended for Mode 1 charging shall provide a protective earthing conductor from the standard plug to the vehicle connector.

Current limitations are also subject to the standard socket-outlet ratings described in **9.2**.

6.2.2 *Mode* **2**

Mode 2 is a method for the connection of an EV to a standard socket-outlet of an a.c. supply network utilizing an a.c. EV supply equipment with a cable and plug, with a control pilot function and system for personal protection against electric shock placed between the standard plug and the EV.

The rated values for current and voltage shall be as follows:

	Single Phase a.c.	Three Phase a.c.
Rated Voltage	240 V	415 V
Maximum rated current	32 A	32 A

Current limitations are also subject to the standard socket-outlet ratings described in **9.2**. EV supply equipment intended for Mode 2 charging shall provide a protective earthing conductor from the standard plug to the vehicle connector.

Mode 2 equipment that is destined to be mounted on a wall but is detachable by the user, or to be used in a shock resistant enclosure shall use protection equipment as required by IEC 62752.

6.2.3 *Mode 3*

Mode 3 is a method for the connection of an EV to an a.c. EV supply equipment permanently connected to an a.c. supply network, with a control pilot function that extends from the a.c. EV supply equipment to the EV.

EV supply equipment intended for Mode 3 charging shall provide a protective earthing conductor to the EV socket-outlet and/or to the vehicle connector.

6.2.4 *Mode 4*

Mode 4 is a method for the connection of an EV to an a.c. or d.c. supply network utilizing a d.c. EV supply equipment, with a control pilot function that extends from the d.c. EV supply equipment to the EV.

Mode 4 equipment may be either permanently connected or connected by a cable and plug to the supply network.

EV supply equipment intended for Mode 4 charging shall provide a protective earthing conductor or protective conductor to the vehicle connector.

Additional requirements for d.c. EV supply equipment are given in IEC 61851-23.

6.3 Functions Provided in Mode 2, 3 and 4

6.3.1 *Mandatory Functions in Modes 2, 3, and 4*

6.3.1.1 *General*

The following control pilot functions shall be provided by the EV supply equipment:

a) Continuous continuity checking of the protective conductor according to **6.3.1.2**;

b) Verification that the EV is properly connected to the EV supply equipment according to **6.3.1.3**;

c) Energization of the power supply to the EV according to **6.3.1.4**;

d) De-energization of the power supply to the EV according to **6.3.1.5**; and

e) Maximum allowable current according to **6.3.1.6**.

Compliance is checked by inspection and test where applicable.

If EV supply equipment can supply more than one vehicle simultaneously, it shall ensure that the control pilot function performs the above functions independently at each connecting point.

NOTE — The control pilot functions can be achieved using a pulse width modulated (PWM) signal and a control pilot as described in Annex A or by any other non PWM system that provides the same results and is compatible with Annex A.

EV supply equipment designed for Mode 2 or Mode 3, using the control pilot conductor and utilizing accessories according to IEC 62196-2, shall be provided with control pilot function according to Annex A.

6.3.1.2 *Continuous continuity checking of the protective conductor*

While charging in Mode 2, the electrical continuity of the protective earthing conductor between the ICCB and the respective EV contact shall be continuously monitored by the ICCB.

While charging in Mode 3, the electrical continuity of the protective earthing conductor between the EV charging station and the respective EV contact shall be continuously monitored by the EV supply equipment.

While charging in Mode 4, the electrical continuity of the protective conductor between the EV charging station and the respective EV contact shall be continuously monitored by the EV supply equipment.

The EV supply equipment shall disconnect the supply to the EV in case of:

a) Loss of electrical continuity of the protective conductor (that is, open control pilot circuit), within 100 ms.
b) Incapacity to verify the continuity of the protective conductor (for example, short circuit between pilot wire and protective conductor), within 3 s.

6.3.1.3 *Verification that the EV is properly connected to the EV supply equipment*

The EV supply equipment shall be able to determine that the EV is properly connected to the EV supply equipment.

Proper connection is assumed when the continuity of the control pilot circuit is detected.

6.3.1.4 *Energization of the power supply to the EV*

The EV socket-outlet or the vehicle connector shall not be energized unless the control pilot function between EV supply equipment and EV has been established correctly with signal states allowing energization.

The presence of such states does not imply that energy will be transferred between the EV supply equipment and the EV as this may be subject to other external conditions, for example, energy management system.

If the EV requests ventilation, the EV supply equipment shall only energize the system if such ventilation is provided by the installation or the premises.

6.3.1.5 *De-energization of the power supply to the EV*

If the control pilot signal is interrupted the power supply to the EV shall be interrupted according to **6.3.1.2**.

If the control pilot signal status no longer allows energization, the power supply to the EV shall be interrupted but the control pilot signalling may remain in operation.

6.3.1.6 *Maximum allowable current*

A means shall be provided to inform the EV of the value of the maximum current it is allowed to draw. The value of the maximum current permitted shall be transmitted and shall not exceed any of the following:

a) The rated output current of the EV supply equipment, and
b) The rated current of the cable assembly.

NOTE — The cable assembly includes Mode 2 and Mode 3 cable assemblies.

The transmitted value may change, without exceeding the maximum allowed current, to adapt to power limitations, for example, for load management.

The EV supply equipment may interrupt the energy supply if the current drawn by the EV exceeds the transmitted value.

6.3.2 *Optional Functions for Modes 2, 3 and 4*

6.3.2.1 *General*

The optional functions that are implemented shall be indicated in the manual and shall fulfil the requirements of **6.3.2**.

Other functions can be provided.

Compliance is checked by inspection and test where applicable.

6.3.2.2 *Ventilation during supply of energy*

EV supply equipment can exchange information with installation regarding the request and presence for ventilation.

NOTE — This is mainly a requirement for indoor charging.

6.3.2.3 *Intentional and unintentional disconnection of the vehicle connector and/or the EV plug*

A mechanical or electromechanical means shall be provided to prevent intentional and unintentional disconnection under load of the vehicle connector and/ or plug according to IEC 62196-1.

NOTE — IEC 62196-1 : 2014 defines three levels of prevention of disconnection as given in the definitions 3.9, 3.10 and 3.11 in the order of increasing constraints, as follows:

a) Unintentional disconnection prevention -> retaining means,
b) Unintentional and intentional disconnection prevention -> latching device, and
c) Unintentional, intentional disconnection and tampering prevention -> locking mechanism.

6.3.2.4 *Mode 4 using the combined charging system*

The combined charging system as described in ‘Annex CC of IEC 61851-23 : 2014 and ISO 17409 shall be so designed that:

a) a.c. chargeable EVs with a basic vehicle inlet do not require any means to protect the EV against d.c. voltage at the inlet; and
b) a.c. EV supply equipment does not require any means to be self-protected against d.c. voltage coming from the EV.

NOTE — Standard sheets for configuration FF of IEC 62196-3 gives dimensions, rating and relevant mechanical functions of the interface FF for d.c. EV charging system C is described in Annex CC of IEC 61851-23 : 2014.

For d.c. charging, digital communication shall be established between the vehicle and the d.c. EV charging station that validates the d.c. energy transfer.

The d.c. supply to the vehicle shall not be connected until such complete validation from the vehicle is achieved.

A combined interface extends the use of a basic interface for a.c. and d.c. charging.

d.c. charging can be achieved by using separate and additional d.c. power contacts to supply d.c. energy to the EV or by using power contacts placed at the position of the a.c. power contacts of a basic interface, if the vehicle connector and the vehicle inlet are both suitable for d.c.

The basic portion of the combined vehicle inlet can be used with a basic connector for a.c. charging only or with a combined connector having separate contacts for a.c. or d.c. charging.

a.c. and d.c. power transfer shall not occur through the combined interface at the same time.

The combined interface used for d.c. charging shall only be used with the "Combined Charging System" described in Annex CC of IEC 61851-23 : 2014.

Analysis and design of the EV supply equipment using a basic interface for d.c. shall apply a risk analysis according to IEC 61508 (all parts) applying a severity level of at least S2 for the function preventing the risk of unintended d.c. voltage output.

NOTE — Such analysis includes the effect of vehicle faults on EV supply equipment.

7 COMMUNICATIONS

7.1 Digital Communication Between the EV Supply Equipment and the EV

Digital communication is optional for Modes 1, 2 and 3.

For Mode 4 the digital communication as described in IEC 61851-24, shall be provided to allow the EV to control the EV supply equipment.

NOTE — Digital communication as described in ISO/IEC 15118 series is also called high level communication.

7.2 Digital Communication Between the EV Supply Equipment and the Management System

Telecommunication network or telecommunication port of the EV supply equipment, connected to the telecommunication network, if any, shall comply with the requirements for connection to telecommunication networks according to **6** of IS 13252 (Part 1) : 2010.

8 PROTECTION AGAINST ELECTRIC SHOCK

8.1 Degrees of Protection Against Access to Hazardous-Live-Parts

The different parts of the EV supply equipment as mentioned shall fulfil the following requirements:

a) IP ratings for enclosures shall be at least as per **12.4.1**;

b) Vehicle connector when mated with vehicle inlet shall be as per **12.4.2**;

c) Plug mated with socket-outlet shall be as per **12.4.2**;

d) Vehicle connector intended for Mode 1 use, not mated: IP24;

e) Vehicle connector intended for Mode 2 use, not mated: IP24 and fulfilling the following:

Minimum opening of the contact equal to the clearance according to IS 15382 (Part 1) considering over voltage category 2 (for example, the value given in IS 15382 (Part 1) for 240 V/415 V is 2.5 kV rated impulse voltage withstand that implies 1.5 mm separation of contacts) and inhibits the charging and warns the user in case of welded contact.

f) Vehicle connector and EV socket-outlet intended for Mode 3 use, not mated: IP24 provided it is associated directly upstream with a mechanical switching device (*see* also **12.3**) and fulfilling one of the following:
    1) Minimum opening of the contact equal to the clearance according to IS 15382 (Part 1) considering overvoltage category 3 (for example, the value given in IS 15382 (Part 1) for 240 V/415 V is 4 kV rated impulse voltage withstand that implies at least 3 mm separation of contacts);
    2) Presence of monitoring of the switching contacts associated with a means to operate another mechanical switching device providing isolating function upstream the above in case of fault of operation of the switching device upstream the accessory; and
    3) Presence of shutters on live entry hole of the socket-outlets or connectors for Case C.

Compliance is checked by inspection and measurement.

8.2 Stored Energy

8.2.1 *Disconnection of Plug Connected EV Supply Equipment*

For plug connected EV supply equipment, where the connection pins are accessible after unplugging, one second after disconnecting the standard plug from the standard socket-outlet, the voltage between any combination of accessible contacts of the standard plug shall be less than or equal to 60 V d.c. or the stored charge available shall be less than 50 µC.

Compliance is checked by inspection and by test with the EV disconnected according to ***2.1.1.5*** *of IS 13252 (Part 1) : 2010.*

NOTE — Requirements for the EV are specified in ISO 17409.

8.2.2 *Loss of Supply Voltage to Permanently Connected EV Supply Equipment*

The voltage between power lines or power lines and protective earthing conductor, when measured at the input supply terminals of the EV supply equipment, shall be less than or equal to 60 V d.c. or the stored energy shall be less than or equal to 0.2 J within 5 s after disconnecting the power supply voltage to the EV supply equipment.

Compliance is checked by inspection and by test with no EV connected to the EV supply equipment according to ***2.1.1.****7 of IS 13252 (Part 1) : 2010.*

8.3 Fault Protection

Fault protection shall consist of one or more protective measures as permitted according to IS 732:

a) Automatic disconnection of supply;

b) Double or reinforced insulation;

c) Electrical separation if limited to the supply of one item of current-using equipment; and

d) Extra low-voltage (safety extra low voltage (SELV) and protected extra low voltage (PELV)).

Electric separation is fulfilled if there is one electrically separated circuit for each EV.

Compliance is checked by inspection.

8.4 Protective Conductor

The protective earthing conductor and the protective conductor shall be of sufficient rating in accordance with requirements of IEC TS 61439-7.

For Modes 1, 2 and 3, a protective earthing conductor shall be provided between the a.c. supply input earthing terminal of the EV supply equipment and the EV.

Mode 4 EV supply equipment shall provide either:

a) A protective earthing conductor from the input earthing terminal of the a.c. supply network to the EV; or

b) A protective conductor from the EV supply equipment to the EV if fault protection is based on electric separation.

For Modes 3 and 4 permanently connected EV supply equipment, protective earthing conductors shall not be switched.

Compliance is checked by inspection.

8.5 Residual Current Protective Devices

EV supply equipment can have one or more connecting points to supply energy to EVs.

Where connecting points can be used simultaneously and are connected to a common input terminal of the EV supply equipment, they shall have individual protection incorporated in the EV supply equipment.

If the EV supply equipment has more than one connecting point that cannot be used simultaneously then such connecting points can have common protection devices.

EV supply equipment that includes a residual current device (RCD) and that does not use the protective measure of electrical separation shall comply with the following:

a) The connecting point of the EV supply equipment shall be protected by an RCD having a rated residual operating current not exceeding 30 mA;

b) RCD(s) protecting connecting points shall be at least type A;

c) RCDs shall comply with one of the following standards: IS 12640 (Part 1), IS 12640 (Part 2), IS/IEC 609472; and

d) RCDs shall disconnect all live conductors.

NOTE — This applies to single-phase or three-phase connecting points.

Where the EV supply equipment is equipped with a socket-outlet or vehicle connector for a.c. use in accordance with IEC 62196 (all parts), protective measures against d.c. fault current shall be taken. The appropriate measures shall be:

a) RCD type B, or

b) RCD type A and appropriate equipment that ensures the disconnection of the supply in case of d.c. fault current above 6 mA.

NOTES

1 The RCDs or the appropriate equipment that ensure the disconnection of the supply in case of d.c. fault can be provided inside the EV supply equipment, in the installation or in both places.

2 Selectivity can be maintained between the RCD protecting a connecting point and an RCD installed upstream when required for service purposes.

8.6 Safety Requirements for Signalling Circuits Between the EV Supply Equipment and the EV

Any circuit for signalling, which extends beyond the EV supply equipment enclosure for connection with the EV (for example, control pilot circuit), shall be extra low voltage (SELV or PELV) according to IS 302 (Part 1).

8.7 Isolating Transformers

Isolating transformers (excluding safety isolating transformers used for signalling) shall comply with the requirements of IS/IEC 61558-1 and IEC 61558-2-4.

Compliance is checked by inspection.

9 CONDUCTIVE ELECTRICAL INTERFACE REQUIREMENTS

9.1 General

Clause **9** provides a description of the conductive electrical interface requirements.

9.2 Functional Description of Standard Accessories

Standard accessories used for EV supply equipment shall be in accordance with IS/IEC 60309-1, IS/IEC 60309-2 or IS 1293. Standard accessories that are intermateable with interfaces described in the IS/IEC 60320 series and IEC 60320 series shall not be used for EV supply equipment.

Compliance is checked by inspection.

9.3 Functional Description of the Basic Interface

General requirements and ratings shall be in accordance with the requirements specified in IEC 62196-1.

The basic interface is specified in **6.5** of IEC 62196-1 : 2014.

The following contacts are indicated, upto three phases (L1, L2, L3):

a) Neutral (N);
b) Protective conductor (PE);
c) Control pilot (CP); and
d) Proximity contact (PP).

It may be used either for single-phase or for three-phase or both.

Ratings and requirements for the use of the basic interface shall conform to configuration type 2 specified in IEC 62196-2.

9.4 Functional Description of the Universal Interface Under Consideration

9.5 Functional Description of the d.c. Interface

General requirements and ratings shall be in accordance with the requirements specified in IEC 62196-1.

The d.c. interface, configurations and ratings are specified in **6.6** and Table 4 of IEC 62196-1 : 2014.

Ratings and requirements for the use of d.c. interface shall comply with requirements either for configuration AA or for configuration FF specified in IEC 62196-3.

9.6 Functional Description of the Combined Interface

The combined interface is specified in **6.7** and Table 5 of IEC 62196-1 : 2014.

General requirements and ratings shall be in accordance with the requirements specified in IEC 62196-1.

Ratings and requirements for the use of the combined interface with alternating current shall be in accordance with the requirements specified for type 2 in IEC 62196-2.

Ratings and requirements for the use of the combined interface with direct current shall be in accordance with the requirements specified for configuration FF in IEC 62196-3.

9.7 Wiring of the Neutral Conductor

Where accessories according to IEC 62196 are used for three phase supply the neutral conductor shall always be wired to the accessories.

Where accessories according to IEC 62196 are used for single phase supply, the terminals L (L1) and N (Neutral) shall always be wired.

Compliance is checked by inspection.

Wiring instructions shall be provided in the manual (*see* **16.1**).

10 REQUIREMENTS FOR ADAPTORS

Vehicle adaptors shall not be used to connect a vehicle connector to a vehicle inlet.

11 CABLE ASSEMBLY REQUIREMENTS

11.1 General

The cable assembly shall be provided with a cable that is suitable for the application. The cable so provided shall conform to the relevant parts of IEC 62893.

Cable assemblies shall not allow transitions from one mode to another. This does not concern Mode 2 cable assemblies that are constructed according to IEC 62752.

11.2 Electrical Rating

For Case C, the voltage and current ratings of the cable assembly shall be compatible with the rating of the EV supply equipment.

For accessories requiring current coding according to Annex B and IEC 62196-2, the maximum value of the current coding as indicated in **B-2** shall be in accordance with the current rating of the cable assembly.

Cables used with accessories according to IEC 62196-2 for Mode 3 Case B, shall have a minimum withstand I^2t value of 75 000 A^2s.

Compliance is checked by inspection.

NOTE — The I^2t value can be evaluated according to **4.4.5.5.2** of IS 732 : 2018.

11.3 Dielectric Withstand Characteristics

Dielectric withstand characteristics of the cable assembly shall be as indicated for the EV supply equipment in **12.7**.

For class I equipment: between live part and earth with test voltage for class I equipment;

For class II equipment: between live part and exposed conductive parts with test voltage for class II equipment.

11.4 Construction Requirements

A cable assembly shall be so constructed that it cannot be used as a cord extension set.

NOTE — As in IEC 62196-1, plugs and connectors are designed not to match each other.

A cable assembly may include one or more cables, which may be in a flexible tube, conduit or wire way.

The cable may be fitted with an earth-connected metal shielding.

The cable insulation shall be wear resistant and maintain flexibility over the full temperature range required by the classification of the EV supply equipment.

Compliance is checked by inspection.

11.5 Cable Dimensions

The maximum cable length is under consideration.

11.6 Strain Relief

The strain relief of the cable in the vehicle connector, EV plug or in the standard plug shall be as specified in the relevant product standard (for example, IEC 62196-1, IS/IEC 60309-1 or IS 1293).

For Case C the strain relief at the EV supply equipment shall be in accordance with the requirements in IEC 62196-1.

11.7 Cable Management and Storage Means for Cables Assemblies

For Case C EV supply equipment, a storage means shall be provided for the vehicle connector when not in use.

For Case C EV supply equipment the lowest point of the vehicle connector when stored shall be located at a height between 0.5 m and 1.5 m above ground level.

For Case C EV charging stations with cables of more than 7.5 m, a cable management system shall be provided. The free cable length shall not exceed 7.5 m when not in use.

Prevention of overheating of cables or cable assemblies used in stored or partially stored position shall be ensured.

Compliance is checked according to Clause ***22*** *of IEC 61316:1999 for cable reel storage.*

12 EV SUPPLY EQUIPMENT CONSTRUCTIONAL REQUIREMENTS AND TESTS

12.1 General

The control means and the protection means in Mode 2 EV supply equipment that is intended to be used both as stationary equipment and as portable equipment shall comply with IEC 62752 in addition to the requirements of this standard.

For Case C EV supply equipment, the output cable assembly is considered part of the assembly for testing purpose.

Electric devices and components of EV supply equipment shall comply with their relevant standards. The tests of devices and components shall be carried out with the specimen, or any movable part of it, placed in the most unfavourable position that can occur in normal use.

For extreme environment or other special service conditions (*see* IEC TS 61439-7).

12.2 Characteristics of Mechanical Switching Devices

12.2.1 *General*

Switching devices within EV supply equipment intended to supply the connecting points shall comply with their relevant standards, with at least the characteristics as given in **12.2**.

12.2.2 *Switch and Switch-Disconnector*

Switches and switch-disconnectors shall comply with IS/IEC 60947-3.

For a.c. applications, switches and switch-disconnectors shall have a rated current, at a utilization category of at least AC-22A, not less than the rated current of the circuit that they are intended to operate in.

For d.c. applications, switches and switch-disconnectors shall have a rated current, at a utilization category of at least DC-21A, not less than the rated current of the circuit that they are intended to operate in.

Compliance is checked by inspection.

12.2.3 *Contactor*

Contactors shall comply with IS/IEC 60947-4-1.

For a.c. applications, contactors shall have a rated current, at a utilization category of at least AC-1, not less than the rated current of the circuit that they are intended to operate in.

For d.c. applications, contactors shall have a rated current, at a utilization category of at least DC-1, not less than the rated current of the circuit that they are intended to operate in.

Compliance is checked by inspection.

12.2.4 *Circuit-Breaker*

Circuit breakers, if any, shall comply with IS/IEC 60898-1 or IS/IEC 60947-2 or IS 12640 (Part 2).

Compliance is checked by inspection.

12.2.5 *Relays*

Relays used to switch the main current path shall comply with IS/IEC 61810-1 with the following minimum characteristics:

a) Fifty thousand cycles, and
b) Contact category: CC 2.

12.2.6 *Inrush Current*

a.c. EV supply equipment shall withstand the inrush current according to **8.2.2** of ISO 17409 : 2015.

The following values are specified in ISO 17409:

a) After closing the contactor in the EV supply equipment at the peak value of the supply voltage, the EV supply equipment shall be able to withstand 230 A peak within the duration of 100 µs; and

b) During the next second the EV supply equipment shall be able to withstand 30 A (rms).

Compliance to this requirement can be verified by test on the complete EV supply equipment or on the individual switching device according IEC TS 61439-7.

NOTE — An example of a test is given in **9.8** of IEC 62752 : 2016.

The protection means shall be selected not to trip for inrush current.

12.2.7 *Residual Direct Current Monitoring Device (RDC MD)*

under consideration.

12.3 Clearances and Creepage Distances

The clearances and creepage distances in the EV supply equipment, installed as intended by the manufacturer, shall be in accordance with the requirements specified in IS 15382 (Part 1).

Parts of the EV supply equipment directly connected to the public a.c. supply network shall be designed according to overvoltage category IV.

Permanently connected EV supply equipment shall be designed according to a minimum overvoltage category III except for the socket-outlet or the vehicle connector in Case C where a minimum overvoltage category II applies.

EV supply equipment supplied through a cable and plug shall be designed according to a minimum overvoltage category II.

Equipment that is intended to be used under the conditions of a higher overvoltage category shall include appropriate overvoltage protective device (*see* **4.3.3.6** of IS 15382 (Part 1) : 2014).

12.4 Ingress Protection

12.4.1 *Degrees of Protection Against Solid Foreign Objects and Water for the Enclosures*

Enclosures of the EV supply equipment shall have an IP degree, according to IS/IEC 60529 as follows:

a) Indoor use: at least IP41; and

b) Outdoor use: at least IP44.

Compliance is checked by test in accordance with IS/IEC 60529.

The minimum IP degree for socket-outlets and the vehicle connectors shall be in accordance with their appropriate standards.

IPX4 may be obtained by the combination of the socket-outlet or connector and the lid or cap, EV supply equipment enclosure or EV enclosure.

12.4.2 *Degrees of Protection Against Solid Foreign Objects and Water for Basic, Universal and Combined and d.c. Interfaces*

The minimum IP degrees for ingress of objects and liquids shall be:

a) Indoor use:
   1) Vehicle connector when mated with vehicle inlet: IP21;
   2) EV plug mated with EV socket-outlet: IP21;
   3) Vehicle connector for Case C when not mated: IP21; and
   4) Vehicle connector for Case B when not mated: IP24.

b) Outdoor use:
   1) Vehicle connector when mated with vehicle inlet: IP44;
   2) EV plug mated with EV socket-outlet: IP44;
   3) Vehicle connector when not mated: IP24;
   4) Vehicle connector for Case B when not mated: IP24; and
   5) Socket-outlet when not mated: IP24.

Compliance is checked by test in accordance with IS/IEC 60529.

IPX4 may be obtained by the combination of the socket-outlet or connector and the lid or cap, EV supply equipment enclosure or EV enclosure.

12.5 Insulation Resistance

The insulation resistance measured with a 500 V d.c. voltage applied between all inputs/outputs connected together (power source included) and the accessible parts shall be:

a) > 1 M Ω for class I EV supply equipment; and

b) > 7 MΩ for class II EV supply equipment.

For this test all extra low voltage (ELV) circuits shall be connected to the accessible parts during the test. The measurement of insulation resistance shall be carried out with the protective impedances disconnected, and after applying the test voltage for the duration of 1 min and immediately after the damp heat continuous test of IS 9000 (Part 4), at 40°C ± 2°C and 93 percent relative humidity for four days.

The conditioning test for the insulation test and the touch current can be avoided if the conditioning for test of **12.9** followed by test of **12.5**, **12.6** and final test of **12.9**, are conducted sequentially in that order.

12.6 Touch Current

The touch current between any a.c. supply network poles and the accessible metal parts connected with each other, and with a metal foil covering insulated external parts, is measured in accordance with IS/IEC 60990 and shall not exceed the values indicated in Table 1.

The touch current shall be measured within one hour after the damp heat continuous test of IS 9000 (Part 4), at 40°C ± 2°C and 93 percent relative humidity for four days, with the electric vehicle charging station connected to a.c. supply network in accordance with IS/IEC 60990.

The test voltage shall be 1.1 times the rated voltage.

This test shall be made when the EV supply equipment is functioning with a resistive load at rated output power.

Circuitry that is connected through a fixed resistance or referenced to earth (for example, proximity function and control pilot function) are disconnected before this test.

The equipment is fed through an isolating transformer or installed in such a manner that it is isolated from the earth.

12.7 Dielectric Withstand Voltage

12.7.1 *a.c. Withstand Voltage*

The dielectric withstand voltage, at power frequency of 50 Hz, shall be applied for 1 min as follows:

a) For a class I EV supply equipment:

(Un + 1 200 V) (r.m.s.) in common mode (all circuits in relation to the exposed conductive parts) and differential mode (between each electrically independent circuit and all other exposed conductive parts or circuits) as specified in **5.3.3.2** of IS 15382 (Part 1) : 2014.

NOTE — Un is the nominal line to neutral voltage of the neutral-earthed supply system.

b) For a class II EV supply equipment:

Two times (Un + 1 200 V) (r.m.s), in common mode (all circuits in relation to the exposed conductive parts) and differential mode (between each electrically independent circuit and all other exposed conductive parts or circuits) as specified in **5.3.3.2.3** of IS 15382 (Part 1) : 2014.

c) For both class I and class II a.c. EV supply equipment where the insulation between the a.c. supply network and the extra low voltage circuit is double or reinforced insulation, 2 times (Un + 1 200 V) (r.m.s.) shall be applied to the insulation.

Alternatively the test can be carried out using a d.c. voltage equal to the a.c. peak values.

For this test, all the electrical equipment shall be connected, except those items of apparatus which, according to the relevant specifications, are designed for a lower test voltage; current-consuming apparatus (for example, windings, measuring instruments, voltage surge suppression devices) in which the application of the test voltage would cause the flow of a current, shall be disconnected. Such apparatus shall be disconnected at one of their terminals unless they are not designed to withstand the full test voltage, in which case all terminals may be disconnected.

NOTE — For test voltage tolerances and the selection of test equipment (*see* IEC 61180).

12.7.2 *Impulse Dielectric Withstand (1.2 µs/50 µs)*

The dielectric withstand of the power circuits at impulse test shall be tested according to IS 15382 (Part 1).

The impulse voltage shall be applied to live parts and exposed conductive parts.

The test shall be carried out in accordance with the requirements of IEC 61180.

Parts of the EV supply equipment directly connected to the public a.c. supply network shall be tested according to overvoltage category IV.

Permanently connected EV supply equipment shall be tested according to an overvoltage category III except for the socket-outlet or the vehicle connector in Case C where an overvoltage category II applies.

EV supply equipment supplied through a cable and plug shall be tested according to an overvoltage category II.

12.8 Temperature Rise

EV supply equipment shall comply with IEC TS 61439-7.

12.9 Damp Heat Functional Test

Following the conditioning defined below, the EV supply equipment is deemed to pass the test, if, it passes the normal sequences test according to **A-4.7** of

Table 1 Touch Current Limits

	Class I	Class II
Between any network poles and the accessible metal parts connected with each other and a metal foil covering insulated external parts	3.5 mA	0.25 mA
Between any network poles and the metal inaccessible parts normally non-activated (in the case of double insulation)	Not applicable	3.5 mA
Between inaccessible and accessible parts connected with each other and a metal foil covering insulated external parts (additional insulation)	Not applicable	0.5 mA

Annex A. The precision of the timing does not need to be verified.

Conditioning:

a) For indoor units, 6 cycles of 24 h each to a damp heat cycling test according to IS 9000 (Part 5/Sec 2) at (40 ± 3)°C and relative humidity of 95 percent; and

b) For outdoor units, two 12 day periods, with each period consisting of 5 cycles of 24 h each to a damp heat cycling test according to IS 9000 (Part 5/Sec 2) at (40 ± 3)°C and relative humidity of 95 percent.

12.10 Operating Temperature Limits

The EV supply equipment shall remain functional at the prescribed ambient temperature limits. The equipment shall withstand the following tests.

12.10.1 *Minimum Temperature Functional Test*

The EV supply equipment shall be pre-conditioned in accordance with IS 9000 (Part 2), at the minimum operating temperature (either -5°C for indoor, -25°C outdoor or value declared by the manufacturer, whichever is lower ± 3 K) for (16 ± 1) h.

The EV supply equipment is deemed to pass the test, if, immediately after the pre-conditioning, it passes the sequences test according to **A-4.7** of Annex A while at the minimum operating temperature. The precision of the timing does not need to be verified.

12.10.2 *Maximum Temperature Functional Test*

The EV supply equipment shall be pre-conditioned in accordance with IS 9000 (Part 3/Sec 3) or IS 9000 (Part 3/Sec 5) as applicable, at the maximum operating temperature (55°C or value declared by the manufacturer, whichever is higher ± 2 K) for (16 ± 1) h.

The EV supply equipment is deemed to pass the test, if, immediately after the pre-conditioning, it passes the sequences test according to **A-4.7** of Annex A while at the maximum operating temperature. The precision of the timing does not need to be verified.

12.11 Mechanical Strength

For Mode 2 EV supply equipment the minimum degree of protection of the external enclosure against mechanical impact shall be IK08 according to IEC 62262.

After the test, the samples shall show that:

a) The IP degree according to **12.5** is not impaired;

b) No part has moved, loosened, detached or deformed to the extent that any safety functions are impaired;

c) The test did not cause a condition that results in the equipment not complying with the strain relief requirements, if applicable;

d) The test did not result in a reduction of creepage and clearance between uninsulated live parts of opposite polarity, uninsulated live parts and accessible dead or grounded metal below the minimum acceptable values; and

e) The test did not result in any other evidence of damage that could increase the risk of fire or electric shock.

13 OVERLOAD AND SHORT-CIRCUIT PROTECTION

13.1 General

Where connecting points can be used simultaneously and are intended to be supplied from the same input line, they shall have individual protection incorporated in the EV supply equipment.

If the EV supply equipment presents more than one connecting point then such connecting points may have common overload protection means and may have common short-circuit protection means, if those protection means provide the required protection for each of the connecting points (for example, the common protection device shall have a rating no higher than the lowest rating of the connecting points).

NOTE — Such a configuration might have an impact on availability, which could be resolved by adequate load management (for example, load sharing).

If the EV supply equipment presents more than one connecting point that cannot be used simultaneously then such connecting points can have common protection means.

Such overcurrent protective devices shall comply with IS/IEC 60947-2, IS/IEC 60947-6-2 or IS 12640 (Part 2) or with the relevant parts of IS/IEC 60898 series or IS 13703 series.

13.2 Overload Protection of the Cable Assembly

The EV charging stations or Mode 2 EV supply equipment shall provide overload protection for all cases for all intended cable conductor sizes if not provided by the upstream supply network.

The overload protection may be provided by a circuit breaker, fuse or combination thereof.

If overload protection is provided by a means other than a circuit breaker, fuse or combination thereof, such means shall trip within 1 min if the current exceeds 1.3 times the rated current of the cable assembly.

13.3 Short-Circuit Protection of the Charging Cable

The EV charging stations or Mode 2 EV supply equipment shall provide short-circuit current protection for the cable assembly if not provided by the supply network.

In case of short-circuit, the value of I^2t at the EV socket-outlet of the Mode 3 charging station shall not exceed 75 000 A^2s.

In case of short-circuit, the value of I^2t at the vehicle connector (Case C) of the Mode 3 charging station shall not exceed 80 000 A^2s.

NOTES

1 This can either be achieved by integrating the appropriate short-circuit protection device in the EV charging station or by providing the relevant information in the installation manual.

2 Protection against short-circuit can be provided inside the EV charging station, in the fixed installation or in both places.

3 The value of 80 000 A^2s is identical to that indicated to ISO 17409 : 2015.

The real value of the prospective short-circuit current is evaluated at the point where the cable assembly is connected.

14 AUTOMATIC RECLOSING OF PROTECTIVE DVICES

The automatic or remote reclosing of protective devices after tripping in the EV supply equipment shall only be possible in case the following requirement is fulfilled:

a) The socket-outlet shall not be mated to a plug. This shall be checked by the EV supply equipment.
b) For automatic or remote reclosing, automatic reclosing devices (ARDs) with an assessment means may be used.
c) The EV supply equipment may close the contactor during an automatic or remote reset cycle to establish conductivity between the protection device and the socket-outlet.
d) By this procedure the EV supply equipment can check the circuit up to the socket-outlet to be free of fault current.
e) For Case C the EV supply equipment shall not provide automatic or remote reclosing of protective devices.

15 EMERGENCY SWITCHING OR DISCONNECT (OPTIONAL)

Emergency switching or disconnect equipment shall be used either to disconnect the supply network from EV supply equipment or to disconnect the socket-outlet(s) or the cable assembly(ies) from the supply network.

Such equipment shall be installed in accordance with IS 732.

Such equipment may be part of the supply network or either the EV charging station or the Mode 2 supply equipment.

16 MARKING AND INSTRUCTIONS

16.1 Installation Manual of EV Charging Stations

The installation manual of EV charging stations shall indicate the classification as given in **5**.

The EV supply equipment manufacturer shall state the interface characteristics specified in clause **5** of IEC TS 61439-7 : 2014 in the manual where applicable. Wiring instructions shall be provided.

If protective devices are included in the EV charging station, the manual shall indicate the characteristics of those protection devices explicitly describing the type and rating. The information may be provided in a detailed electric diagram.

If the protective devices are not in the EV charging station, the manual shall indicate all information necessary for the installation of external protection explicitly describing the type and rating of the devices to be used.

It is recommended that the installation manual be made available to future customers.

If the EV charging station has more than one connection of the equipment to the a.c. supply network, and does not have individual protection for each connecting point to the vehicles, then the installation manual shall indicate that each connection of the equipment to the a.c. supply network requires individual protection.

The installation manual shall indicate if the optional function for ventilation is supported by the charging station (**6.3.2.2**).

The installation manual shall indicate ratings or other information that denote special (severe or unusual) environmental conditions of use (*see* **5.3**).

16.2 User Manual for EV Supply Equipment

User information shall be provided by the manufacturer on the EV supply equipment or in a user’s manual.

Such information shall state:

a) Which adaptors or conversion adapters are allowed to be used,
b) Which adaptors or conversion adapters are not allowed to be used,
c) That adaptors or conversion adapters are not allowed to be used,

and

d) That cord extension sets are not allowed to be used.

The user manual shall include information about usage restrictions.

16.3 Marking of EV Supply Equipment

16.3.1 The EV supply equipment manufacturer shall provide each EV supply equipment with one or more labels marked in a durable manner and located in a place such that they are visible and legible during installation and maintenance:

a) EV supply equipment manufacturer’s name, initials, trade mark or distinctive marking;
b) Type designation or identification number or any other means of identification, making it possible

to obtain relevant information from the EV supply equipment manufacturer; and

c) "Indoor Use Only", or the equivalent, if intended for indoor use only.

16.3.2 The EV supply equipment manufacturer shall provide each EV supply equipment with one or more labels, marked in a durable manner and located in a place such that they are visible and legible during installation:

a) Means of identifying date of manufacture;
b) Type of current;
c) Frequency and number of phases in case of alternating current;
d) Rated voltage (input and output if different);
e) Rated current (input and output if different) and the ambient temperature used to determine the rated current;
f) Degree of protection;
g) All necessary information relating to the special declared classifications, characteristics and diversity factor(s), severe or unusual environmental conditions of use (*see* **5.3**); and
h) Country of manufacture.

Compliance is checked by inspection and by 16.5.

16.4 Marking of Charging Cable Assemblies Case B

Cable assemblies for Mode 1 Case B or Mode 3 Case B shall be marked in a durable manner with the following information:

a) Manufacturer's name or trade mark;
b) Type designation or identification number or any other means of identification, making it possible to obtain relevant information from the manufacturer;
c) Rated voltage;
d) Rated current;
e) Number of phases; and
f) Degree of protection.

Marking for the entire cable assembly shall be provided in a clear manner by a label or equivalent means.

Compliance is checked by inspection and by ***16.5****.*

16.5 Durability Test for Marking

Marking made by moulding, pressing, engraving or similar, including labels with a laminated plastic covering, shall not be submitted to the following test.

The markings required by this standard shall be legible with corrected vision, durable and visible during use.

Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.

NOTE — The petroleum spirit is defined as a solvent hexane with a content of aromatics of maximum 0.1 percent in volume, a kauri-butanol value of 29, an initial boiling point of 65°C, a final boiling point of 69°C and a density of approximately 0.68 g/cm^3.

After the test, the marking shall be legible to normal or corrected vision without additional magnification. It shall not be easily possible to remove marking plates and they shall show no curling.

ANNEX A

(*Clauses* 6.3.1.2, 12.9,12.10)

CONTROL PILOT FUNCTION THROUGH A CONTROL PILOT CIRCUIT USING A PWM SIGNAL AND A CONTROL PILOT WIRE

A-1 GENERAL

This annex describes the control pilot function through a control pilot circuit using pulse width modulation (PWM) for Mode 2, Mode 3 and Mode 4.

Two types of control pilot function are possible:

a) Simplified (**A-2.3**), and

b) Typical (**A-2.2**).

This annex describes the circuit parameters and sequencing of events for these control pilot functions.

Additional requirements for implementation in Mode 4 system are described in IEC 61851-23.

Annex A is applicable to EV supply equipment and EVs using a control pilot function based on a PWM signal over the control pilot circuit.

A-2 CONTROL PILOT CIRCUIT

A-2.1 General

Figures A-1 and A-2 illustrate an electric equivalent circuit of the control pilot circuit. The EV supply equipment shall set the duty cycle of the PWM control pilot signal to indicate the maximum current according to Table A-7. The indicated maximum current transmitted shall not exceed the value according to **6.3.1.6**.

The EV supply equipment may open the switching device that energizes the EV if the EV draws a higher current than the PWM signal (duty cycle) indicates. In this case, the EV supply equipment shall respect the following

conditions:

a) The allowed response time of the EV, according to Table A-6 (for example, sequence 6).

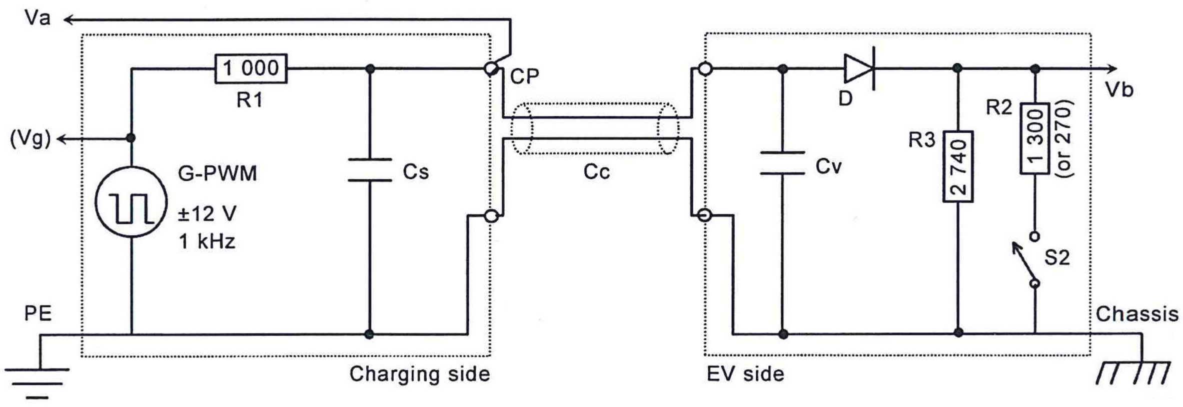
b) The current tolerance related to the duty cycle generated by the EV supply equipment (1 percentage point).

c) The tolerances of the current measurement used in the EV supply equipment itself.

NOTE — Total tolerances might be higher than 15 percent.

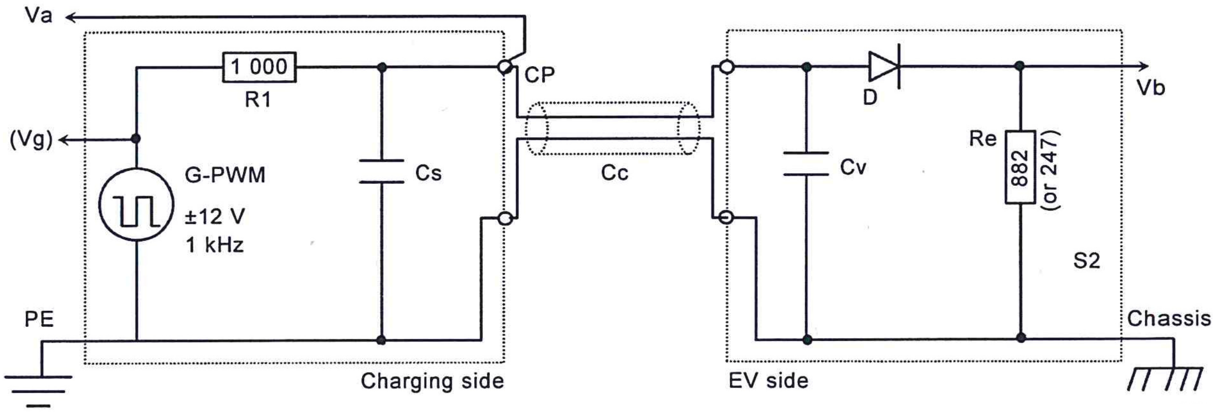
The control pilot circuit shall be designed in accordance with Fig. A-1 or A-2 with the values defined in Table A-2, Table A-3 and Table A-4.

The functionality of the control pilot circuit shall follow the requirements defined in Table A-4, Table A-6, Table A-7 and Table A-8.



Key			
G-PWM	PWM signal generator for pilot function	Vb	EV measurement of voltage, duty cycle and frequency
Va	Pilot wire voltage measured at EV supply equipment output	CP	control pilot contact
Vg	Internal voltage of PWM signal generator	Chassis	vehicle chassis connection
R1,Cs	as defined in Table A-2		
R2,R3,Cv,D	as defined in Table A-3		

FIG. A-1 TYPICAL CONTROL PILOT CIRCUIT (EQUIVALENT CIRCUIT)



Key

G-PWM	PWM signal generator for pilot function	Vb	EV measurement of voltage, duty cycle and frequency
Va	Pilot wire voltage measured at EV supply equipment output	CP	control pilot contact
Vg	Internal voltage of PWM signal generator	Chassis	vehicle chassis connection
R1,Cs	as defined in Table A-2		
Re,Cv,D	as defined in Table A-3		

FIG. A-2 SIMPLIFIED CONTROL PILOT CIRCUIT (EQUIVALENT CIRCUIT)

A-2.2 Typical Control Pilot Circuit

The EV supply equipment communicates by setting the duty cycle of a PWM signal or a continuous d.c. voltage signal (Table A-7).

The EV supply equipment may change the duty cycle of the PWM signal at any time.

The EV responds by applying a resistive load to the positive half-wave to the control pilot circuit.

For further information about the PWM signal see also Table A-2, Table A-3 and Table A-4.

EVs using typical control pilot circuit (Fig. A-1) shall be able to create state B and use it according to the sequences specified in Table A-6.

EV using a typical control pilot circuit shall determine the maximum current from EV supply equipment from the duty cycle of the PWM signal (Table A-8).

A-2.3 Simplified Control Pilot Circuit

An EV using the simplified control pilot circuit shall limit itself to single phase charging and shall not draw a current of more than 10 A.

EV supply equipment that supports an EV using the simplified control pilot shall modulate the PWM signal in the same manner as done for EVs using the typical control pilot circuit.

EVs using simplified control pilot circuit (Fig. A-2) are not able to create state B.

An EV using the simplified control pilot circuit can measure the duty cycle.

The designer of an EV using the simplified control pilot should be aware that the EV supply equipment can open its switching device, if the EV supply equipment indicates less current (by the duty cycle) than the EV draws (*see* **A-2.1**).

It is not recommended to use the simplified control pilot circuit for new EV design.

A-2.4 Additional Components and High Frequency Signals

Digital communication as described in ISO/IEC 15118 series may be carried out over the control pilot conductor. Additional components can be needed to couple this high-frequency signal onto the control pilot signal.

Additional components required for signal coupling shall not deform the control pilot signal beyond the limits defined in Tables A-2 and A-4.

Conformity is tested according to ***A-4.6***.

The maximum inductance of the control pilot circuit of the EV supply equipment is limited to 1 mH (*see* Table A-3).

The maximum inductance of the control pilot circuit of the EV is limited to 1 mH (see Table A-2).

NOTE — ISO 15118-3 provides guidance on selection of components that provide damping.

The additional signal for digital communication shall have a frequency of at least 148 kHz.

The voltage of the high frequency signal (used for digital communication) shall be in accordance with the values given in Table A-1.

One further capacitive (max of 2 000 pF) branch (on the vehicle and on the EV supply equipment) can be used for detection of the high frequency signals, provided the resistance/impedance to ground is higher than 10 kΩ. Such capacitive/resistive branch would typically be used for signal inputs and automatic signal voltage control (refer to Table A-1).

A-3 REQUIREMENTS FOR PARAMETERS AND SYSYTEM BEHAVIOUR

The control pilot circuit parameters shall be in accordance with Table A-2 and Table A-3 and are shown in Fig. A-1 and A-2.

Table A-1 Maximum Allowable High Frequency Signal Voltages on Control Pilot Conductor and the Protective Conductor

Frequency kHz	Max Peak/ Peak Voltage V
148-249	0.4
250-499	0.6
500-1 000	1.2
>1 000	2.5

Table A-2 Control Pilot Circuit Parameters and Values for the EV Supply Equipment

Parametera	Symbol	*Min.* Value	Typical Value	*Max.* Value	Unit	Remark
Generator open circuit positive voltage c)	Voch	11.4	12	12.6	V	
Generator open circuit negative voltage c)	Vocl	-12.6	-12	-11.4	V	
Frequency generator output	Fo	980	1 000	1 020	Hz	
Pulse width b) c)	Pwo	Per Table A-7 –5µs	Per Table A-7	Per Table A-7 + 5µs	µs	
Rise time (10 percent to 90 percent) c)	Trg	—		2	µs	Design value for the oscillator.
Fall time (90 percent to 10 percent) c)	Tfg	—		2	µs	Design value for the oscillator.
Settling time to 95 percent steady state c)	Tsg	—		3	µs	Design value for the oscillator.
Equivalent source resistance	R1	970	1 000	1 030	Ω	970 Ω to 1 030 Ω 1 percent equivalent resistors commonly recommended
EV supply equipment capacitance d)	Cs	300	—	1 600	pF	
Cable capacitance	Cc	—	—	1 500	pF	Case B (cord set)
Optional series (damped) inductance e)	Lse	—	—	1	mH	Maximum value allowed on off board EV supply equipment

a) Tolerances to be maintained over the full useful life and under environmental conditions as specified by the manufacturer.

b) At 0 V crossing of the 12 V signal.

c) At point Vg as indicated on Fig.A-1 and Fig. A-2.(to be measured at output – open circuit).

d) For Mode 3 Case C and for a Mode 2 cord set the max equivalent capacitance is total of Cc + Cs.

e) Damped inductance. Nominal values of additional components such as L and required damping (R-damp)) used for high-frequency signal, are defined in Table A-11 of ISO 15118-3 : 2015.

EV pilot circuit values and parameters as indicated on Fig. A-1 and A-2 are given in Table A-3.

Value ranges shall be maintained over full useful life and under design environmental conditions.

One percent tolerance resistors are commonly recommended for this application.

Table A-4 indicates the pilot voltage range based on components values in Tables A-2 and A-3. It incorporates an increased voltage margin for Va to allow for measurement tolerances of the EV supply equipment.

Table A-3 EV Control Pilot Circuit Values and Parameters and Values for the EV

Parameter	Symbol	*Min.* Value	Typical Value	*Max.* Value	Unit
Permanent resistor value (Fig. A-1)	R3	2 658	2 740	2 822	Ω
Switched resistor value for vehicles not requiring ventilation (Fig. A-1)	R2 State Cx	1 261	1 300	1 339	Ω
Switched resistor value for vehicles requiring ventilation (Fig. A-1)	R2 State Dx	261.9	270	278.1	Ω
Equivalent total resistor value no ventilation (Fig. A-2)	Re State Cx	856	882	908	Ω
Equivalent total resistor ventilation required (Fig. A-2)	Re State Dx	239	246	253	Ω
Diode (D) voltage drop (2.75 – 10 mA, -40°C to + 85°C)	Vd	0.55	0.7	0.85	V
Reverse recovery time	Tr	—	—	200	ns
Total equivalent input capacitance [a)]	Cv	—	—	2 400	pF
Optional additional series (damped) inductance[b)]	Lsv	—		1	mH

[a)] For Mode 3 Case A the max equivalent capacitance is total of Cc + Cv. Cc is given in Table A-2.

[b)] Damped inductance. Stray and additional components such as RDamp, L used for high-frequency signal, are defined in Table A-11 of ISO 15118-3 : 2015.

There is no undefined voltage range, for the PWM signal, between the system states.

The state is valid if it is within the above values. The state detection shall be noise resistant, for example, against EMC and high frequency data signals on the control pilot circuit.

For reliable detection of a state, it is recommended to apply averaging of the measurement over several milliseconds or PWM cycles.

The EV supply equipment shall verify that the EV is properly connected by verifying the presence of the diode in the control pilot circuit, before energizing the system. This shall be done at the transition from x1 to x2 or at least once during state x2, before closing the supply switching device. Presence of the diode is detected if the low side of the PWMsignal is within the voltage range defined in Table A-4.

The EV supply equipment shall open or close the supply switching device within the time indicated in Table A-6.

Table A-4 System States Detected by the EV Supply Equipment

Va[a]			PWM Status[b]	System State	EV Connected to the EV Supply Equipment	S2[d]	EV Ready to Receive Energy[e]	EV Supply Equipment Ready to Supply Energy[f]	Remark
Lower Level V	**Nominal V**	**Higher Level V**							
11	12	13	Off	A1	no	N/A	No	Not Ready	Vb = 0 V
11	12	13	On	A2[g]			No	Ready	
10		11	on or off	Ax or Bx[h]	no/yes	open	No	State Dependent	
8	9	10	Off	B1	yes	open	No	Not Ready	Re = R3 = 2.74 kΩ detected
8	9	10	On	B2[g]			No	Ready	
7		8	On or off	Bx or Cx[h]		open/close	State dependent		
5	6	7	Off	C1		close	Yes	Not Ready	Re = 882 Ω detected EV does not require charging area ventilation
5	6	7	On	C2[c),g)]			Yes	Ready	
4		5	on or off	Cx or Dx[h]			Yes	State dependent	
2	3	4	Off	D1			Yes	Not Ready	Re = 246 Ω detected EV requires charging area ventilation
2	3	4	On	D2[c),g)]			Yes	Ready	
1	N/A	2	On or off	Dx or E[h]		Open or closed	State dependent		
-1	0	1	Off	E	N/A	N/A	N/A	Not Ready	
-10		-1	On or Off	Invalid[c]	N/A	N/A	N/A		Fault in control circuit[c]
-11		-10	Off	F or invalid	N/A	N/A	N/A	Not Ready	
-13	-12	-11	Off	F	N/A	N/A	N/A	Not Ready	
-11		-10	On	x2 or Invalid[h]	No/Yes	open/close	State dependent		[c]
-13	-12	-11	On	x2[c]	N/A	N/A	State dependent		Low side of PWM signal[c]

Voltage values, Va, as indicated in the table are informative, actual values to be tested according to **A-4**.

[a] All voltages are measured after stabilization period. It is recommended for the EV supply equipment to use Vg as reference for the measurement of Va.

[b] PWM status "on" describes a generated square wave voltage of +/-12 V. PWM status "off" describes a steady state d.c. voltage.

[c] The EV supply equipment shall check PWM signal low state of -12 V, diode presence, at least once before the closing of the supply switching device on the EV supply equipment.

[d] S2 = Switch in the EV (*see* Fig. A-1).

[e] EV ready to receive energy = EV ready for power transfer by closing S2 contacts.

[f] EV supply equipment ready to supply energy = ready –> PWM status "on", not ready –> PWM status "off".

[g] Negative voltage range tolerances of the PWM signal are defined by "Low side of PWM -signal" row (last row).

[h] A control pilot circuit defines its own trigger level to separate the states inside this voltage range. It is recommended to use different trigger level depending on the direction of the state change to include hysteresis behaviour.

Compliance is tested as in **A-4**.

The state changes between A, B, C and D are caused by the EV or by the user.

The state changes between state x1 and x2 are created by the EV supply equipment.

A change between states x1 and x2 indicates an availability (x2) or unavailability (x1) of power supply to the EV.

After changing to state F and while the reason for changing to state F persists, an EV supply equipment with permanently attached cable (Case C) shall:

a) remain in state F, or

b) remain in state F for at least 300 ms and then change to state x1 (and stays there), in order to detect if an EV is connected.

If the failure is not recovered after disconnecting the vehicle connector, the EV supply equipment shall:

a) remain in or change to state F, or

b) remain in state x1, if the EV supply equipment provides an indicator (for example, a display) which shows “not available”.

In the absence of a fault condition in the EV supply equipment, the EV supply equipment shall not use the state F in order to signal that the EV supply equipment will not deliver the energy to the EV. Instead, this shall be done by the state x1.

A transition from state E or state F to any other state (x1 or x2) is allowed.

If the EV is connected to the EV supply equipment which does not use 5 percent duty cycle, and authentication (for example, radio-frequency identification (RFID) identification, payment, etc.) is needed, the control pilot signal shall stay at x1 as long as the energy is not allowed to be supplied. In case, no authentication is needed, the system may go to state x2.

In case EV supply equipment requires authentication to supply power, a change from states CX or DX to state BX shall not lead to loss of authentication. This means that no repeated authentication shall be needed.

See Figures A-3 and A-4 for state diagrams.

Table A-5 State Behaviour

Sl. No. (1)	States (2)	Description (3)	Behaviour (4)
i)	x1[a)]	The EV supply equipment will not deliver the energy, for example: a) Due to the lack of available power in the grid for supply. b) The EV supply equipment has intentionally stopped due to intermittent or other power supply limitations.	If energy is available, the EV supply equipment will change to x2[b)] according to sequence 3.1 or 3.2 in Table A-6. The EV may use this transition as a trigger to start or resume charging.
ii)	State E	This state is generally caused by an error condition, for example: a) No power to the EV supply equipment (for example, a.c. voltage outage). b) Short circuit between control pilot and the protective conductor. This state shall not intentionally be used by the EV supply equipment for signaling, except the work around in **A-5.3**.	The EV supply equipment unlatches/unlocks the socket-outlet at maximum of 30 s, if any.
iii)	State F	This state is intentionally set by the EV supply equipment to signal a fault condition, for example: a) maintenance of the EV supply equipment is needed	The EV supply equipment unlatches/unlocks the socket-outlet at maximum of 30 s, if any.

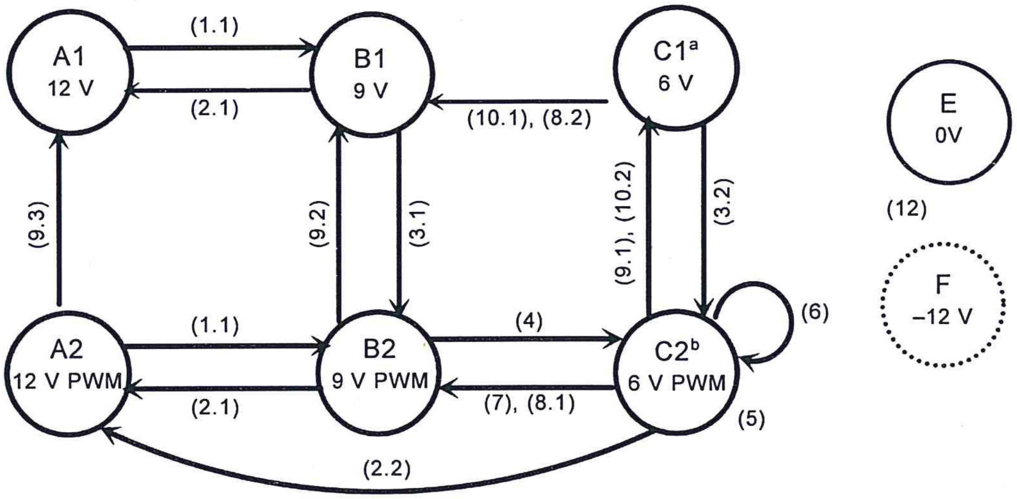
NOTES

1 In case of a power outage and if the EV supply equipment has a backup battery, the EV supply equipment can stay in state x1. After the drainage of the battery, the EV supply equipment will enter state E.

2 In case of state F and if the EV supply equipment is able to unlatch / unlock the socket-outlet via user interaction (e.g. authorisation) there is no need to unlatch / unlock within 30 s according to sequence 12 in Table A-6.

[a)] State x1 can be referred to state A1 or state B1 or state C1 or state D1.

[b)] State x2 can be referred to state B2 or state C2 or state D2.



Numbers in brackets refer to the sequence reference in Table A-6.

A change from any state to state Ax, E or F may take place at any time.

a) Can be state D1 (3V).

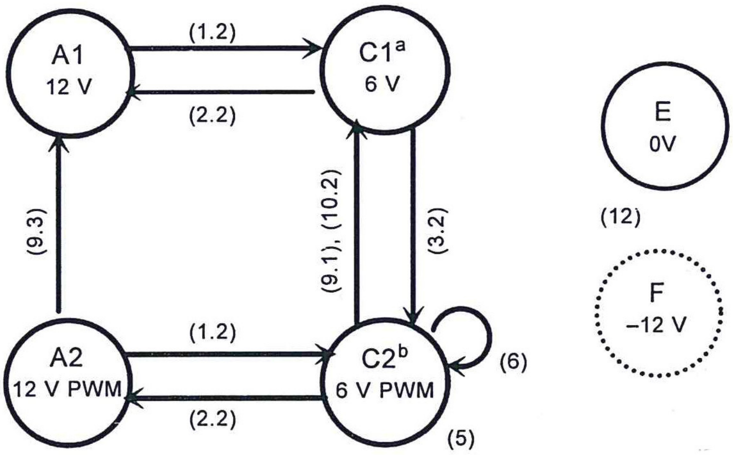
b) Can be state D2 (3V PWM).

Not all state changes and sequences described in Table A-6 are shown in this figure, for example, a change from any state to state Ax, state E or state F may take place at any time.

FIG. A-3 STATE DIAGRAM FOR TYPICAL CONTROL PILOT (INFORMATIVE)

Table A-6 indicates the principle sequences and transitions from one state to another with the timing requirements where applicable. Some transitions that may take place are not indicated in the table.

If the EV supply equipment or the EV changes to a new state within the timing indicated for that sequence, the new sequence is initiated and replaces the previous sequence.



Numbers in brackets refer to the sequence reference in Table A-6.

Not all state changes and sequences described in Table A-6 are shown in this figure, for example, a change from any state to state Ax, state E or state F may take place at any time.

a) Can be state D1, (3V); or

b) Can be state D2, (3V PWM).

FIG. A-4 STATE DIAGRAM FOR SIMPLIFIED CONTROL PILOT (INFORMATIVE)

TABLE A-6 LIST OF SEQUENCES

Table A-6 Sequence 1.1 Plug-in (With S2)

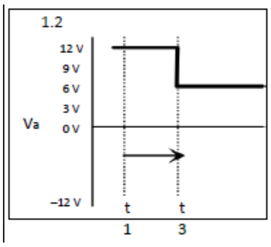
Example Diagrams	**State or Transition**	**Conditions**	**Timing**
 a.c. supply remains off S2 remains open a.c. current remains off Trigger: n/a	A1 A1→B1 or A2→B2 (not shown in image)	(1) EV not connected +12 V (2) The cable assembly is connected to the vehicle and to the EV supply equipment, +9 V.	$(t_2\text{-}t_1)$ = No max[a]

Table A-6 Sequence 1.2 Plug-in (w/o S2 or S2 Always in Close Position)

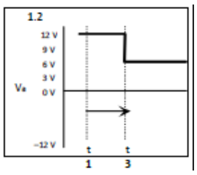
Example Diagrams	**State or Transition**	**Conditions**	**Timing**
 a.c. supply remains off S2 already or always closed a.c. current remains off Trigger: n/a	A1 A1→C1/D1 or A2→C2/D2 (not shown in image)	(1) EV not connected +12 V (3) The cable assembly is connected to the vehicle and to the EV supply equipment NOTES **1** This sequence indicates EV operates in simplified control pilot function. **2** t2 does not exist in this sequence. **3** In case this sequence 1.2, the EV supply equipment can assume EV operates in simplified control pilot and may not follow the current limitation indication by PWM. To detect if the EV operates in simplified control pilot, it is recommended for the EV supply equipment to start in state A1.	$(t_3\text{-}t_1)$ = No max[a]

Table A-6 Sequence 2.1 Unplug at State Bx

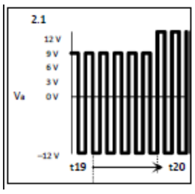
Example Diagrams	**State or Transition**	**Conditions**	**Timing**
 a.c. supply remains off S2 remains open a.c. current remains off Trigger: n/a	B2→A2 or B1→A1 (not shown in image)	(19) Plug disconnected from the EV supply equipment or vehicle connector disconnected from the vehicle inlet. (20) EV not connected The EV supply equipment shall allow removal of the plug automatically, at a maximum of 5 s, when entering state A (Case A or B) unless the locking was initiated through user interaction (for example, authorization). Then unlatching / unlocking can be done only by using the adequate user interaction or both. In Case A, EV with attached cable, a switch may be added on the control pilot circuit, on the EV side (cable, plug, vehicle), to simulate the EV disconnection (state A).	$(t_{20}\text{-}t_{19})$ = No max[a]

Table A-6 Sequence 2.2 Unplug at State Cx, Dx

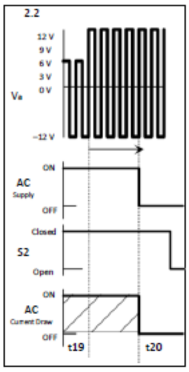
Example Diagrams	State or Transition	Conditions	Timing
 2.2 12 V 9 V 6 V 3 V 0 V Va −12 V ON AC Supply OFF Closed S2 Open ON AC Current Draw OFF t19 t20	C2, D2 → A2	(19) In case of a failure, if: a) the control pilot circuit is broken, b) the plug disconnected from the EV supply equipment under load, or c) the vehicle connector disconnected from the vehicle inlet under load. The EV supply equipment shall open its switching device. The EV shall open its S2, if any.	$(t_{20}-t_{19})$ = Max 100 ms from t_{19} Max 3 s
Trigger: C2 (or D2) → A2	C2, D2 → A2	(19) In case of normal operation: a) the plug disconnected from the EV supply equipment not under load. or b) the vehicle connector disconnected from the vehicle inlet not under load. The EV supply equipment shall open its switching device. The EV shall open its S2, if any.	$(t_{20}-t_{19})$ = Max 100 ms from t19 Max 3 s
Trigger: C1 (or D1) → A1	C2, D2→ A2 or C1, D1→ A1	(19) EV not connected The EV supply equipment shall allow removal of the plug automatically, at a maximum of 5 s, when entering state A (Case A or B) unless the locking was initiated through user interaction (for example, authorization). Then unlatching / unlocking can be done only by using the adequate user interaction or both. In Case A, EV with attached cable, a switch may be added on the pilot line, on the EV side (cable, plug, vehicle), to simulate the EV disconnection (state A), an EV that uses this, needs to make sure that the load is below 1 A.	

Table A-6 Sequence 3.1 EV Supply Equipment Power Available (State B)

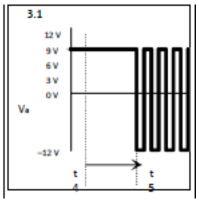
Example Diagrams	State or Transition	Conditions	Timing
 3.1 12 V 9 V 6 V 3 V 0 V Va −12 V t 4 t 5 a.c. supply remains off S2 remains open a.c. current remains off Trigger: EV supply equipment is able to supply energy	B1→B2	(5) The EV supply equipment is now able to supply power, and indicates the maximum current by the PWM duty cycle. The EV may detect this transition from B1 to B2, example, for wake-up. NOTE — This sequence can take place in the beginning of a charging session or to resume a charging session.	(t_5-t_4) = No *Max*[a]

Table A-6 Sequence 3.2 EV Supply Equipment Power Available (State C)

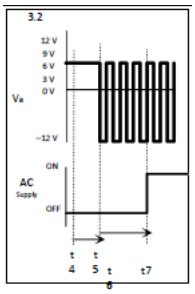
Example Diagrams	State or Transition	Conditions	Timing
 3.2 12 V 9 V 6 V 3 V 0 V Va −12 V ON AC Supply OFF t 4 t 5 t 6 t7 S2 remains closed a.c. current remains off Trigger t_4: EV supply equipment is able to supply energy Trigger t_5: C1→C2 or D1→D2	C1→C2 Or D1→D2 (not shown in image)	(5) The EV supply equipment is now able to supply energy, and indicates the maximum current by the PWM duty cycle.	(t_5-t_4) = No *Max*[a]
		(6) The EV is ready to receive energy.	(t_6-t_5) = 0 s
		(7) EV supply equipment energizes the system. If state D2 is detected, the supply will close only if ventilation requirements are met. If the duty cycle is equivalent to 5 percent the EV Supply Equipment may not energize the system without digital communication (*see* Table A-8). NOTE — Maximum values for the inrush current of the EV are defined in ISO 17409.	(t_7-t_6) = *Max* 3 s

Table A-6 Sequence 4 EV Ready to Charge

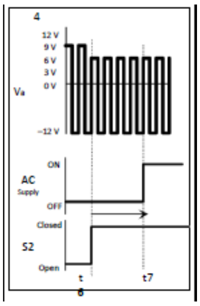
Example Diagrams	State or Transition	Conditions	Timing
 4 12 V 9 V 6 V 3 V 0 V Va −12 V ON AC Supply OFF Closed S2 Open t 6 t7 a.c. current remains off Trigger: B2→C2,D2	B2→C2,D2	(6) The EV is ready to receive energy. (7) EV supply equipment energizes the system, unless the EV supply equipment changes within the 3 s timing to another state (for example, C1).	(t_7-t_6) = *Max* 3 s
	C2,D2	If state D2 is detected, the supply will close only if ventilation requirements are met. In case of an EV asks for ventilation delay, ventilation command turns on after transition from state C2 to state D2 in 3 s. in case the EV supply equipment does not have ventilation, it shall open its switching devices and may change to state x1. NOTE — In case of 5 percent duty cycle, the amount of current is indicated by the digital communication; the EV supply equipment may close the supply switching device only after the authorization given by digital communication. NOTE — Maximum values for the inrush current of the EV are defined in ISO 17409.	

Table A-6 Sequence 5 EV Starts Charging

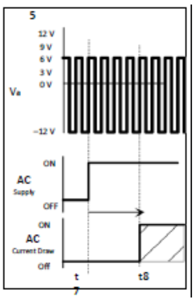
Example Diagrams	State or Transition	Conditions	Timing
 5 12 V 9 V 6 V 3 V 0 V Va –12 V ON AC Supply OFF ON AC Current Draw Off t 7 t8 S2: remains closed Trigger: a.c. supply to EV	C2, D2	(8) Charge current drawn by the EV within the limit indicated by the duty cycle of the PWM signal given in Table A-8. NOTE — Maximum values for the inrush current of the EV are defined in ISO 17409.	$(t_8\text{-}t_7)$ = No *Min*, No *Max*[a]

Table A-6 Sequence 6 Current Change

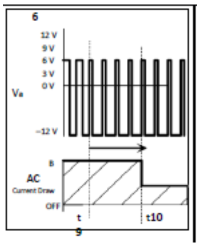
Example Diagrams	State or Transition	Conditions	Timing
 6 12 V 9 V 6 V 3 V 0 V Va –12 V B AC Current Draw OFF t 9 t10	C2, D2	(9) EV supply equipment indicates an adjustment to the maximum a.c. line current. Such a change may originate from the grid, by manual settings or automatic changes calculated by the EV supply equipment. The EV supply equipment may change the PWM duty cycle at any time to any valid PWM duty cycle. In normal operation, during the 5 s allowed adjustment time $(t_{10}\text{-}t_9)$, the EV supply equipment shall not initiate a new sequence 6 for changing the PWM.	Max 10 s From the instant when the EV supply equipment gets the status and responds by adjusting the duty cycle
a.c. supply remains available S2 remains closed Trigger: PWM duty cycle change		(10) The EV shall adjust its maximum current drawn to be equal or below the maximum current indicated by the PWM duty cycle.	$(t_{10}\text{-}t_9)$ = *Max* 5 s

Table A-6 Sequence 7 EV Stops Charging

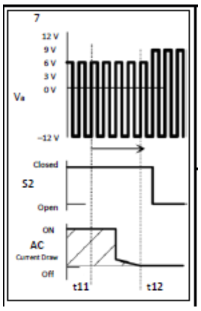
Example Diagrams	State or Transition	Conditions	Timing
 7 12 V 9 V 6 V 3 V 0 V Va –12 V Closed S2 Open ON AC Current Draw Off t11 t12	C2, D2	(11) In normal operation an EV shall decrease the current draw to minimum (less than 1 A) before opening S2. During a non-normal operation (emergency) the EV may open S2 immediately.	$(t_{12}\text{-}t_{11})$ = No *Max*[a]
	C2, D2 → B2	(12) The EV opens S2.	
a.c. supply remains available Trigger: n/a			

Table A-6 Sequence 8.1 EV Supply Equipment Responds to EV Opens S2 (with PWM)

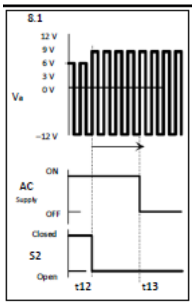
Example Diagrams	State or Transition	Conditions	Timing
 8.1 12 V 9 V 6 V 3 V 0 V Va –12 V ON AC Supply OFF Closed S2 Open t12 t13 a.c. current draw: off and remains off Trigger: C2/D2 → B2	B2	(13) The EV supply equipment shall open its switching device responding to a state change from state C2/D2 to state B2. (During a non-normal operation (emergency), the switching device might have to open under load).	$(t_{13}\text{-}t_{12})$ = *Max* 100 ms

Table A-6 Sequence 8.2 EV Supply Equipment Responds to EV Opens S2 (w/o PWM)

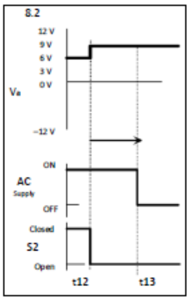
Example Diagrams	State or Transition	Conditions	Timing
 8.2 12 V 9 V 6 V 3 V 0 V Va –12 V ON AC Supply OFF Closed S2 Open t12 t13 a.c. current draw: off and remains off Trigger: C1/D1 → B1	B1	(13) The EV supply equipment shall open its switching device responding to a state change from state C1/D1 to state B1. An EV using the simplified pilot circuit is not able to generate this sequence.	$(t_{13}\text{-}t_{12})$ = *Max* 100 ms

Table A-6 Sequence 9.1 EV Supply Equipment Requests to Stop Charging

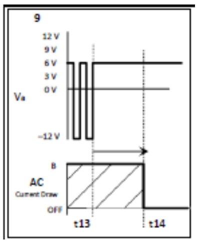
Example Diagrams	State or Transition	Conditions	Timing
 9 12 V 9 V 6 V 3 V 0 V Va –12 V B AC Current Draw OFF t13 t14 a.c. supply remains on S2 remains closed Trigger: C2, D2→C1, D1	C2, D2→C1, D1	(13) EV supply equipment may change to state x1 in order to indicate the EV to stop the current draw.	$(t_{14}\text{-}t_{13})$ = *Max* 3 s
	C1, D1	(14) The EV shall respond to the steady state PWM, and stops the current draw.	
		The EV supply equipment may open its switching device if the vehicle load current exceeds the maximum current indicated by PWM according to Table A-8.	

Table A-6 Sequence 9.2 EV Supply Equipment Stops PWM at State B

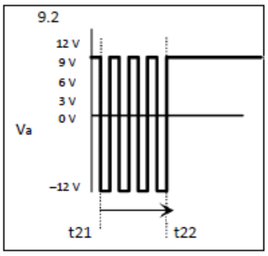
Example Diagrams	State or Transition	Conditions	Timing
 a.c. supply remains off S2 remains open a.c. current draw remains zero Trigger: n/a	B2 → B1	(22) EV supply equipment may stop the PWM at any time. No action by the EV needs to take place. In case sequence 3.1 will follow sequence 9.2, the EV supply equipment shall wait at least 3 s. NOTE — This sequence might interfere with time triggered charging or preconditioning of the EV	$(t_{22}-t_{21})$ = No *Max*[a]

Table A-6 Sequence 9.3 EV Supply Equipment Stops PWM at State A

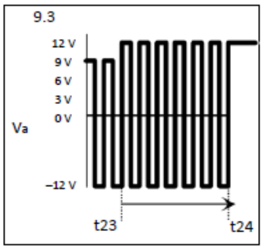
Example Diagrams	State or Transition	Conditions	Timing
 a.c. supply remains off S2 remains open a.c. current draw remains zero Trigger: B2/C2/D2 → A2	A2 → A1	(23) EV supply equipment may stop the PWM at any time. (24) No action by the EV needs to take place. EV disconnected.	$(t_{24}-t_{23})$ = No *Max*[a]

Table A-6 Sequence 10.1 EV Responds to Stop Charging Request

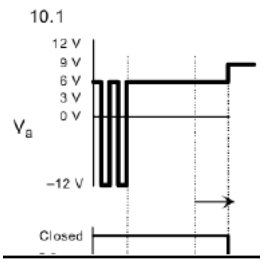
Example Diagrams	State or Transition	Conditions	Timing
 a.c. supply remains on Trigger: EV stops current draw		This sequence follows sequence 9.1. and the EV responds to the steady state by stopping the current draw.	
	C1, D1→B1	(15) The EV shall open S2.	$(t_{15}-t_{14})$ = *Max* 3 s
	This sequence shall be followed by sequence 8.2. An EV using the simplified pilot circuit is not able to generate this sequence		

Table A-6 Sequence 10.2 EV Does Not Respond to a Stop Charging Request

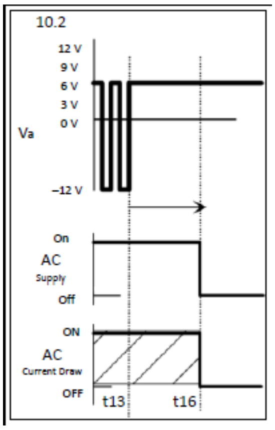
Example Diagrams	State or Transition	Conditions	Timing
 10.2 12 V 9 V 6 V 3 V 0 V Va –12 V On AC Supply Off ON AC Current Draw OFF t13 t16 S2 remains closed Trigger: C2/D2 → C1, D1	C1, D1	This sequence follows sequence 9.1, but the EV does not respond to the steady state and does not stop the current draw, contrary to sequenc 9.1. (16) The EV supply equipment may open its switching device under load. (Timer starts upon the PWM change) NOTE — t_{15} does not exist due to any change of S2 in this sequence.	$(t_{16}$-$t_{13})$ = *Min* 6 s

Table A-6 Sequence 11 EV Signal to the EV Supply Equipment

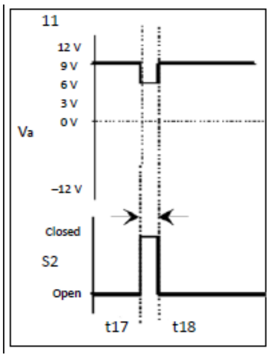
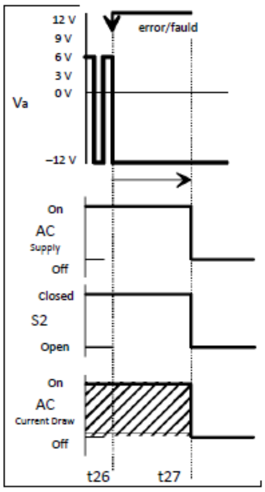
Example Diagrams	State or Transition	Conditions	Timing
 11 12 V 9 V 6 V 3 V 0 V Va –12 V Closed S2 Open t17 t18 a.c. supply remains off a.c. current draw remains off Trigger: see ISO/IEC 15118	Bx→Cx/Dx →Bx	(17, 18) A transition from state Bx to Cx or Dx and Cx or Dx to Bx. The EV supply equipment shall not move to state F due to sequence 11. This sequence is optional, and shall be used only with digital communication (ISO/IEC 15118 series). This sequence may be used by the EV in order to signal the EV supply equipment (for example, wakeup the digital modem). EV shall not draw current during this sequence.	$(t_{18}$-$t_{17})$ = *Min* 200 ms, *Max* 3 s

Table A-6 Sequence 12 State Caused by Error or Fault Condition

Example Diagrams	State or Transition	Conditions	Timing
 12 V 9 V 6 V 3 V 0 V Va –12 V error/fauld On AC Supply Off Closed S2 Open On AC Current Draw Off t26 t27	XX → F XX → E (not shown in image)	Changing from any state to state E, the EV supply equipment switching device shall be open.	$(t_{27}-t_{26})$ = *Max* 3 s
		EV shall open S2, if any.	$(t_{27}-t_{26})$ = *Max* 3 s
		The EV supply equipment unlatches / unlocks the socket-outlet if any. (Timing not shown on diagram). NOTE — In Case B and if the cable assembly belongs to the EV supply equipment owner, the unlatching / unlocking is at the EV supply equipment owner's discretion.	*Max* 30 s

Trigger: any state
→ E or F

NOTES

1. If locking is used, the EV supply equipment shall latch/lock the plug connected to the socket-outlet before closing its switching device, according to IEC 62196 series.

2. a) Va – Voltage of the control pilot at the socket-outlet or at the vehicle connector (as shown in Fig. A-1 and Fig. A-2).

b) a.c. supply — Status of the relays/contactor at the EV supply equipment (EV supply equipment is ready to supply energy).

c) S2 — Switching contacts terminals of the EV switch.

d) a.c. current draw — EV can draw electric energy.

[a] The indication "No Max" implies that the delay time has no constraints and may depend on external influences and the conditions existing on the EV supply equipment or the EV.

Table A-7 PWM Duty Cycle Provided by EV Supply Equipment

Maximum Current Iav	Nominal Control Pilot Duty Cycle D_N	Description
Iav = 0 A	D_N = 0 percent	Continuous -12 V, EV supply equipment not available; state F
	D_N = 100 percent	No current available — state x1 (see Table A-5)
Maximum current is indicated via digital communication	D_N = 5 percent	A duty cycle of 5 percent indicates that digital communication is required and shall be established between the EV supply equipment and EV before enabling energy supply. If digital communication cannot be established, the EV supply equipment shall: a) stay in 5 percent duty cycle, b) change to x1 (100 percent duty cycle) for at least 3 s, or c) change to x1 (100 percent duty cycle) for at least 3 sand then change to a duty cycle between 10 percent and 96 percent.
6 A ≤ Iav ≤ 51 A	D_N = Iav / 0.6 A	10 percent ≤ D_N ≤ 85 percent
51 A < Iav ≤ 80 A	D_N = (Iav / 2.5 A + 64)	85 percent < D_N ≤ 96 percent

NOTE — Duty cycle tolerances are indicated in Table A-2.

Table A-8 Maximum Current to be Drawn by Vehicle

Control Pilot Duty Cycle Din at EV Plug (In Case A) or Vehicle Inlet	Maximum Current Imax.to be Dawn by Vehicle	Description
Duty cycle < 3 percent	0 A	Drawing current not allowed
3 percent ≤ D_{in} ≤ 7 percent	As indicated by digital communication	A duty cycle of 5 percent indicates that digital communication according to ISO/IEC 15118 series or IEC 61851-24 is required and shall be established between the EV supply equipment and the EV before energy supply. Drawing current is not allowed without digital communication. Digital communication may also be used with other duty cycles.
7 percent < D_{in} < 8 percent	0 A	Drawing current not allowed
8 percent ≤ D_{in} < 10 percent	6 A	
10 percent≤ D_{in} ≤ 85 percent	D_{in} × 0.6 A	
85 percent < D_{in} ≤ 96 percent	(D_{in} – 64) × 2.5 A	
96 percent< D_{in} ≤ 97 percent	80 A	
97 percent < D_{in} ≤ 100 percent	0 A	Drawing current not allowed

If the PWM signal is between 8 percent and 97 percent and there is a digital communication established, the maximum current shall not exceed the current indicated by the lower value of either the PWM signal or the digital communication.

In 3-phase systems, the duty cycle value indicates the current limit per each phase.

The EV supply equipment can start at any valid value of the duty cycle, and may change during power supply.

The EV shall detect the frequency. In case the frequency is outside of (1 ± 5 percent) kHz, the EV should not charge. For EVs using the simplified control pilot this is not applicable.

The value given as "Maximum current (I_{max}) to be drawn by vehicle" does not cover either inrush current or leakage current such as current flowing to y-capacitors.

A-4 TEST PROCEDURES

A-4.1 General

This **A-4** describes tests for immunity of EV supply equipment to wide tolerances on the control pilot circuit and the presence of high frequency data signals on the control pilot circuit. The EV supply equipment is designed to be in conformity with the parameters as defined in **A-2** and **A-3**. However, it is necessary for the EV supply equipment to be tolerant to slight parameter changes (due for example to poor contacts or leakage on the control pilot circuit) in order to ensure reliable supply of energy to EVs under most conditions.

A-4.2 Constructional Requirements of the EV Simulator

Testing is done using an EV simulator on the control pilot circuit that allows the testing in normal operation and at the tolerance limits allowed for the voltage and including the imposition of a high frequency signal on the control pilot circuit. The test scheme described in **A-4** allows the testing of the EV supply equipment when in normal operation and when subjected to high frequency imposed signals on the control pilot circuit.

An EV simulator shall have the possibility of testing the EV supply equipment with all three possible resistor values as indicated in Table A-9 with the following values for the other components.

a) Cv test shall use the maximum value from Table A-3 (including the 1 000 pF of the generator);

b) Lsv test shall use the maximum allowed value from Table A-3;

c) Cc test shall use the maximum value from Table A-2;

d) The high frequency test signal shall be injected at the EV supply equipment socket-outlet for Cases A and B, and at the vehicle coupler for Case C;

e) The diode shall conform with the specifications in Table A-3; and

f) The 9 test resistor values shall be within a tolerance of 0.2 percent of the value indicated in Table A-9.

Table A-9 Test Resistance Values

Test Resistor	Minimum Value	Nominal Value	Maximum Value
R3 test (Ω)	1 870	2 740	4 610
R2 test (Ω) state Cx	909	1 300	1 723
R2 test (Ω) state Dx	140	270	448

This table is not applicable to values used on vehicles (*see* Table A-3).

NOTE — An example of a test setup is described in **A-4.10**, Fig. A-8.

A-4.3 Test Procedure

The proper function of the EV supply equipment shall be tested under the following conditions.

A sine wave generator with an impedance of 50 Ω is connected to the control pilot circuit via a 1 000 pF capacitor, as shown in Fig. A-8.

The output amplitude of the sine wave generator has to be adjusted in such a way that the high frequency voltage component on the control pilot conductor is 2.5 V peak at 1 MHz, measured at the EV socket-outlet (Case A and B) or the vehicle connector (Case C or a Mode 2 cable assembly) in state B at the beginning of each sequence.

The frequency of the sine wave generator shall sweep through the frequency range from 1 MHz to 30 MHz with a logarithmic step width of 4 percent and a holding time of 0.5 s.

Unless otherwise specified, input voltage from power supply shall be the rated value, within the range of its tolerance.

NOTE — The measure of the control pilot wire will take place on the EV supply equipment, socket-outlet or plug, in Case A and Case B, and on the EV coupler in Case C.

A-4.4 Oscillator Frequency and Generator Voltage Test

R2 test (state Cx), R2 test (state Dx) and R3 test shall be at the nominal value for this test.

The frequency shall be within ± 0.5 percent of 1 000 Hz at state B2 and C2 and D2 (if ventilation supported).

Frequency and voltage shall be measured at the contacts CP and PE of the EV socket-outlet (in Case A and Case B) or of the vehicle connector (in Case C or Mode 2 cable assembly).

The precision of measurements of voltages for this test shall be better than ± 0.5 percent.

The voltage measured at the EV supply equipment output shall be as given in Table A-10.

The internal resistor of the EV supply equipment (R1_calc) value is calculated by the formula:

$$R1\_calc = 2\,740 \times (U\_StateA - U\_StateB) / (U\_StateB - 0.7)$$

U_state A and U_state B are the two positive voltage values measured during the test of Table A-10 and VR2 is the value of the positive voltage across $R2_{test}$ in state B.

R1_calc shall be 1 000 Ω ± 3 percent.

A-4.5 Duty Cycle Test

Duty cycle shall be tested at 5 percent (if any), 10 percent and the maximum current declared by the EV supply equipment manufacturer (in case the EV supply equipment cannot change the PWM it shall be tested only at the default duty cycle).

R2 test (state Cx), R2 test (state Dx) and R3 test shall be at the nominal value for this test.

The measurement shall be carried out at the contacts CP and PE of the socket-outlet (in Case A and Case B) or of the vehicle connector (in Case C).

The duty cycle shall be evaluated at 0 V crossing.

Table A-10 Parameters of Control Pilot Voltages

	Minimum Voltage	Maximum Voltage
In state A1 and positive part of PWM signal in state A2	11.4	12.6
In state B1 and positive part of PWM signal in state B2	8.37	9.59
In state C1 and positive part of PWM signal in state C2	5.47	6.53
Negative part of PWM signal in states A2 and B2	-12.6	-11.4

Table A-11 Test Parameters of Control Pilot Signals

Parameter		Maximum Value	Unit
Rise time (10 percent to 90 percent)	State B	10	µs
	State C	7	µs
	State D[a]	5	µs
Fall time (90 percent to 10 percent)	States B, C, D[a]	13	µs

NOTE Signals are evaluated for the values of the nominal resistance in the control pilot test circuit in Table A-9.

a In case ventilation is supported by the EV supply equipment.

Table A-12 Parameters for Sequence Tests

	R3 Test Ω	R2test Ω State Cx	R2test Ω State Dx	HF Voltage
Test 1	4 610	1 723	448	Not present
Test 2	4 610	1 723	448	Present
Test 3	1 870	909	140	Not present
Test 4	1 870	909	140	Present

Resistances tolerance is better than or equal to ± 0.2 percent.

HF voltage test is only required for EV supply equipment designed for digital communication. Lower voltages may apply for EV supply equipment not designed for digital communication systems.

Note — HF voltage test is under consideration in ISO 15118-3.

A-4.6 Pulse Wave Shape Test

The PWM pulse shape shall be within the values indicated in Table A-11.

$R2_{test}$ (state Cx), $R2_{test}$ (state Dx) and $R3_{test}$ shall be at the nominal value for this test.

A-4.7 Sequences Test

A-4.7.1 *General*

This test checks the a.c. supply and the timing in order to test the operation at the maximum and minimum allowed voltage levels.

These tests verify the operation of the pilot control over a complete cycle using the resistance values defined in Table A-12.

In case the EV supply equipment cannot change the PWM duty cycle, there is no need to meet sequence 6.

For the EV supply all sequences need to be checked with the timing according to Table A-6. A minimum delay of 20 s shall separate the sequences unless a shorter delay is required by Table A-6.

The EV simulator shall wait for at least 20 s in case of a "no max" requirement for the EV before proceeding with the next step.

Unlatching / unlocking of the coupler in the EV supply equipment, if any, needs to take place according to Table A-5.

Four complete standard charging cycles shall be performed using the resistor values indicated in Table A-12. The EV supply equipment shall be deemed to have failed the test if the cycle is not completed.

A-4.7.2 *Sequence Test Using the Typical Control Pilot Circuit*

Fig. A-5 shows a charging sequence using the typical control pilot circuit.

Test the EV supply equipment by simulating an EV using the typical control pilot circuit 1.1 —> 3.1 —> 4

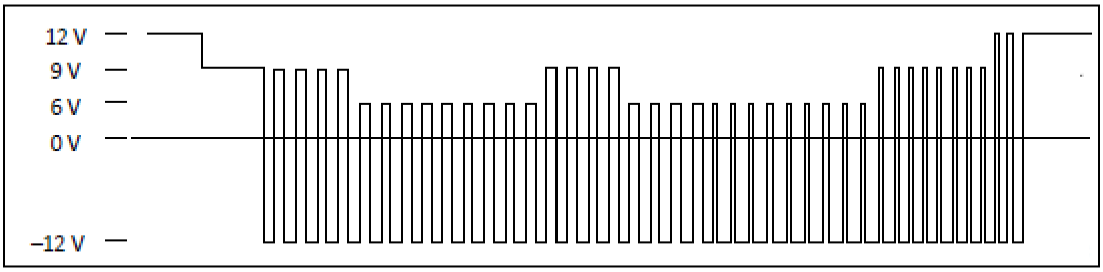


FIG. A-5 TEST SEQUENCE USING A TYPICAL CONTROL PILOT CIRCUIT

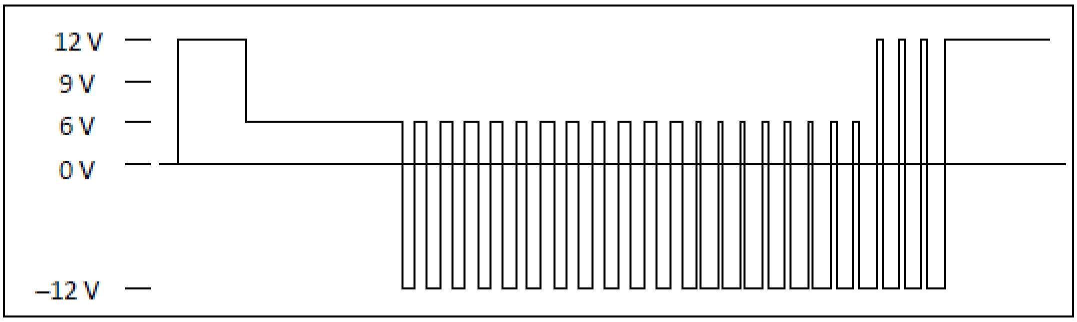


FIG. A-6 TEST SEQUENCE USING THE SIMPLIFIED CONTROL PILOT CIRCUIT

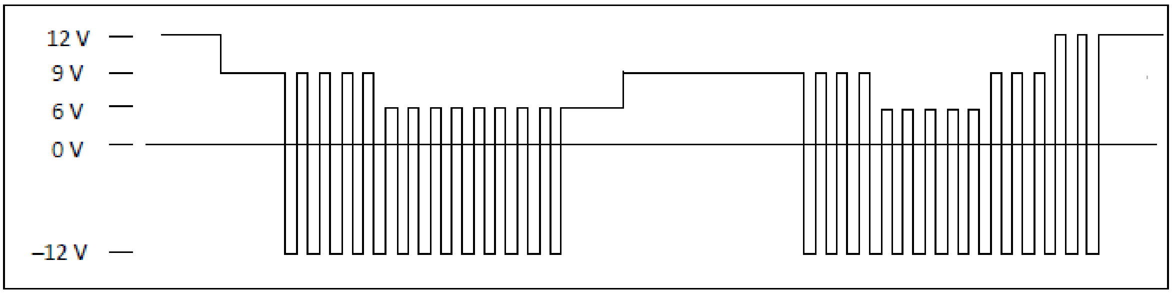


FIG. A-7 OPTIONAL TEST SEQUENCE WITH INTERRUPTION BY EV SUPPLY EQUIPMENT

—> 7 —> 8.1.—> 4 —> 6 —> 7 —> 8.1 —> 2.1.—> 9.3 as shown in Fig. A-5.

A-4.7.3 *Sequence Test Using the Simplified Control Pilot Circuit*

Test the EV supply equipment by simulating an EV using the simplified control pilot circuit using sequences 1.2 —> 3.2 —> 5 —> 6 —> 2.2 as shown in Fig. A-6.

A-4.7.4 *Optional Testing the EV Supply Equipment that Support Grid*

Optional testing the EV supply equipment that support grid management by simulating an EV using the typical control pilot circuit is shown in Fig. A-7.

This test is done using the nominal values of R2 (state Cx), R2 (state Dx) and R3 given in Table A-12 using the sequences:

1.1 —> 3.1 —> 4 —> 9.1 —> 10.1 —> 8.2 —> 3.1 —> 4 —> 7 —> 8.1 —> 2.1—> 9.3

During sequence 4, go to state E and disconnect the power from the EV supply equipment.

A-4.8 Test of Interruption of the Protective Conductor

The EV supply equipment shall cut off the power in *max.* 100 m after the protective conductor is interrupted (test is also a part of Table A-13).

Test shall be initiated in state C or D that has been attained for at least 5 s. A supplementary switching device disconnects the protective conductor between the EV supply equipment and the EV or EV simulator.

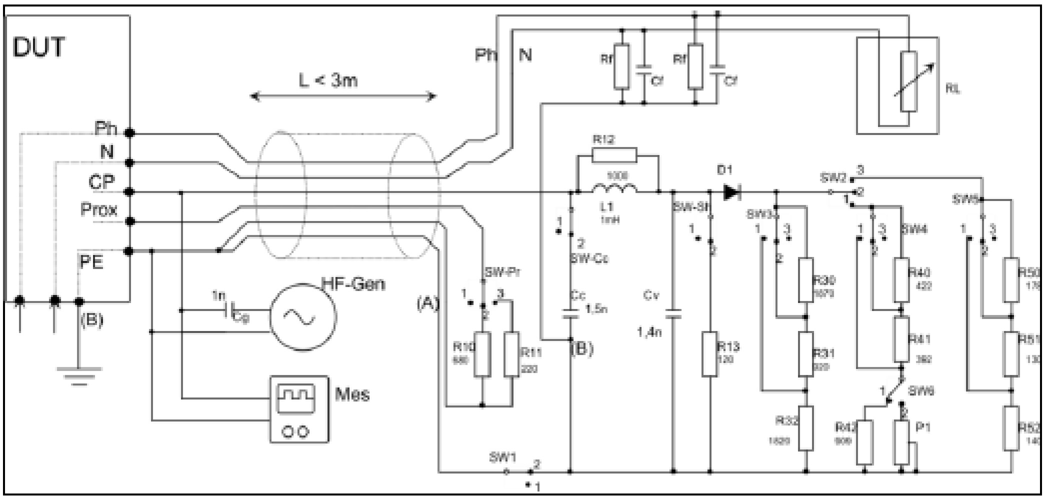
A-4.9 Test of Short-Circuit Values of the Voltage

This test verifies compliance with the timing requirement of Table A-6 sequence 12.

The test shall be initiated with R2 test and R3 test at the nominal value. When state C or D has been attained for at least 5 s, a supplementary resistance of 120 Ω is switched to connect between the control pilot conductor and the protective conductor.

A-4.10 Example of a Test Simulator of the Vehicle (Informative)

Fig. A-8 gives an example of a possible test circuit that allows the simulation of the electric vehicle during charge. The switching of the resistor values (refer to Table A-12) allows the extreme voltage values to be tested according to Table A-9. The signal generator simulates the presence of an imposed high frequency data carrier.



Key	
DUT	EV supply equipment to be tested
CP	Control Pilot contact
Prox	Proximity contact
HF-Gen	1 MHz – 30 MHz sine wave generator 50 Ω output
Mes	pulse width, voltage and HF voltage measurement
D1	fast turn off diode (for example, 1N4934, [Irms = 1 A, Vr >100 V, Tr = 200 ns])
R30, R31, R32, R40, R41, R42, R50, R51, R52	See Note 2
Cv,Cg	See Note 2
SW-Pr, R10, R11	Proximity and current coding for connector type 2, Cases A and B (circuit for connector type 1 not shown). Other values can be added if required (See Clause B-2).
SW-Cc, Cc	Cable capacity. Position 2 is used for Case A and Case B.
SW-Sh,R13	Control Pilot short-circuit test
RL	Load representative of vehicle current
Cf, Rf	Y capacitors for HF filtering (47 nF) and resistors (1 MΩ)
L1, R12	Lse as defined in Table A-2 (max. value)
(A),(B)	See Note 3 and Note 4

Fig. A-8 Example of a Test Circuit (Ev Simulator)

NOTES

1 The HF-Gen and the measurement device are connected as close as possible to the EV socket-outlet (Cases A and B) or the EV plug (Case C).

2 Usage of SW2,SW3,SW4, SW5and SW6:

The switch S2 in Fig. A-1 is simulated by SW2 as follows:

a) Position 2: state Bx (S2 is open);
b) Position 1: state Cx (S2 is closed); and
c) Position 3: state Dx (S2 is closed).

The resistance R2 in Fig. A-1 is simulated by SW4 and resistors R40 (422 Ω), R41 (392 Ω) and R42 (909 Ω) with SW6 in position 1, as follows:

a) Position 2: R2 test has its nominal value;
b) Position 1: R2 test has the minimum test value for state Cx;
c) Position 3: R2 test has the maximum test value for state Cx; and
d) Position 2 of SW6 is used to test the hysteresis of the EV supply equipment detection device (*see* A-4.11).

The resistance R2 in Fig. A-1 for state Dx is simulated by SW5 and resistors R50 (178 Ω), R51 (130 Ω) and R52 (140 Ω) as follows:

a) Position 2: R2 test has its nominal value for state Dx;
b) Position 1: R2 test has the minimum test valuefor state Dx; and
c) Position 3: R2 test has the maximum test value for state Dx.

The resistance R3 in Fig. A-1 is simulated by SW3 and resistors R30 (1 870 Ω), R31 (920 Ω) and R32 (1 820 Ω) as follows:

a) Position 2: R3 test has its nominal value;
b) Position 1: R3 test has the minimum test value; and
c) Position 3: R3 test has the maximum test value.

3 The proximity circuit is normally part of the EV plug. It can be included in the test equipment. Two earth lines are indicated on the figure for clarity but a single line is sufficient.

4 The simulation circuit has no direct connection to the earthing terminal of the DUT and no direct connection to the protective earthing circuit of the test site.

5 Charging cable length test equipment is less than 3 m.

6 Metal film resistors are used with 0.2 percent tolerance or better. Most of these resistances can be chosen from the E48 preferred resistance value table as indicated in Table 2, 4.2 of IS 824:1965. The resistors R31and R32 can be chosen from the E192 table. Their values can also be established using several resistors from the E48.

7 High quality switches (for example, gold or silver plated contacts) are used.

Table A-13 Position of Switches

	State\Switch		Pr	Sh	SW1	SW2	SW3	SW4	SW5	SW6
1	A	Unplugged	1	1	1	X	X	X	X	1
2	Earth Fault	Open earth wire	X	1	1	X	X	X	X	1
3	E		2,3	2	2	2	X	X	X	1
4	B	Nominal values	2,3	1	2	2	2	X	X	1
5	C		2,3	1	2	1	2	2	X	1
6	D		2,3	1	2	3	2	X	2	1
7	B	Upper values	2,3	1	2	2	3	X	X	1
8	C		2,3	1	2	1	3	3	X	1
9	D		2,3	1	2	3	3	X	3	1
10	B	Lower values	2,3	1	2	2	1	X	X	1
11	C		2,3	1	2	1	1	1	X	1
12	D		2,3	1	2	3	1	X	1	1
13	B – C	Hysteresis	2,3	1	2	1	2	1	X	2
14	C – D		2,3	1	2	1	2	1	X	2
15	C – E		2,3	1	2	1	2	1	X	2
16	D – E		2,3	1	2	1	2	1	X	2

Table A-13 defines the switch positions for the different operation conditions. It allows the simulation of the complete test cycles using the nominal resistances, or the tolerance limit values of the EV resistances. Out of bound values can also be created.

For tests at nominal values, SW1 and SW2 are used to switch between states A, B, C and D. Nominal values of the resistance are obtained with SW3, SW4, SW5, in position 2 and SW6 in position 1.

SW-Cc is placed in position 1 for Case C, and in position 2 for Case A and Case B

A-4.11 Optional Hysteresis Test

A-4.11.1 *General*

Slight hysteresis is generally used to improve the reliability of EV Supply Equipment. The test for hysteresis is done by modifying the value of R2 of Fig. A-1during the state C. The potentiometer P1 is used.

The test is done without the presence of a superimposed high frequency signal.

The voltage between the pilot wire terminals and the ground are monitored using a volt meter or similar.

It is not necessary to connect a load to the EV supply equipment during this test.

The initial value of the potentiometer P1 at the beginning of the test is set as indicated in Table A-14.

Table A-14 Initial Settings of the Potentiometer at the Beginning of Each Test

Hysteresis Between States	Initial Resistance
B-C	1 300 Ω
C-D	1 300 Ω
C-E	1 300 Ω
D-E	270 Ω

A-4.11.2 *Test Sequence for Hysteresis Between States B and C*

P1 is set to 1 300 Ω.

The charging system is brought to state C2 that results in the closing of the supply switching device.

The value of P1 is increased slowly so that the voltage on the pilot wire increases at less than 0.01 V/s, until the switching device open. The voltage on the pilot wire at the instant of opening is noted.

The value of P1 is decreased slowly so that the voltage on the pilot wire increases at less than 0.01 V/s, until the switching device closes. The voltage on the pilot wire at the instant of closing is noted.

A-4.11.3 *Test Sequence for Hysteresis Between States C-E, D-E*

P1 is set to 1 300 Ω for C-E and 270 for D-E.

The charging system is brought to state C2 or D2 that results in the closing of the switching device.

The value of P1 is decreased slowly so that the voltage on the pilot wire decreases at less than 0.01 V/s, until the switching device opens. The voltage on the pilot wire at the instant of opening is noted.

The value of P1 is increased slowly so that the voltage on the pilot wire increases at less than 0.01 V/s, until the switching device closes. The voltage on the pilot wire at the instant of closing is noted.

A-4.11.4 *Test Sequence for Hysteresis Between States C-D*.

P1 is set to 1 300 Ω.

The charging system is brought to state C2 that results in the closing of the switching device.

The value of P1 is decreased slowly so that the voltage on the pilot wire decreases at less than 0.01 V/s, until the ventilation switching device closes. The voltage on the pilot wire at the instant of closing is noted.

The value of P1 is increased slowly so that the voltage on the pilot wire increases at less than 0.01 V/s, until the ventilation switching device opens. The voltage on the pilot wire at the instant of opening is noted.

A-5 IMPLEMENTATION HINTS

A-5.1 Retaining a Valid Authentication Until Reaching CP State B

In case authentication (for example, via RFID card) is needed, the EV supply equipment should implement two time-out supervision mechanisms as follows:

a) Time-out supervision from successful authentication until inserting the plug into the socket-outlet of the EV supply equipment (if applicable, that is, Case A and Case B). In Case C, this time-out supervision is not necessary; and
b) Time-out value from successful authentication and plugging the plug into the socket-outlet of the EV supply equipment (if applicable, that is, Case A and Case B) until inserting the vehicle connector into the vehicle inlet (if applicable, that is, Case B and Case C).

Selecting the appropriate values for these two time-outs should be left to the charge point operator who should select these values based on local circumstances like:

a) Distance between location of the authentication module and socket-outlet;
b) Granting access to the vehicle connector or the socket-outlet, respectively, only after successful authentication: yes/no. etc.

If one of these time-out supervisions detects a time-out, the authentication should be invalidated.

A-5.2 Load Control Using Transitions Between State x1 and x2

Repeated transitions between states x1 and x2 can cause excessive wear on elements within the EV. It is therefore recommended to minimize the number of transitions between states x1 and x2.

Load control should preferably be implemented by adjustment of the duty cycle in state x2.

A-5.3 Information on Difficulties Encountered with some Legacy EVs for Wake-up After a Long Period of Inactivity (Informative)

This is a proposition that is written, only to resolve some difficulties encountered on legacy EVs.

No new EV shall implement a system that is dependent on this proposition which is only “a work-around”.

There are a number of EVs that exist that do not “wake-up” by detecting the transition B1/B2 as indicated in the sequence **3.1** or **3.2**.

This is not considered as normal operation with regard to the text in this Annex A, and no new vehicle would encounter this difficulty if it conforms to this Annex A.

It would be possible for EV supply equipment to re-initialize the charging sequence on such legacy EVs by imposing a 0 V on the control wire (thus giving an equivalent of state E) for more than 4 s and thus re-initialize the charging sequence. Such re-initialisation would only be necessary if vehicles do not respond to the transition for 30 s. However note that such re-initialization may pose further problems on other EVs and the reproducibility of the resulting charging sequence cannot be guaranteed.

In case the EV supply equipment changes the duty cycle from 5 percent to a duty cycle between 10 percent and 96 percent, or vice versa, this change may be done in the same way, as described in ISO 15118-3.

EV supply equipment could also implement alternative work-around based on, for example use of state F which is reserved for error signalling, to attain the same. The resultant reaction of the EV supply system to such a situation cannot be guaranteed.

ANNEX B

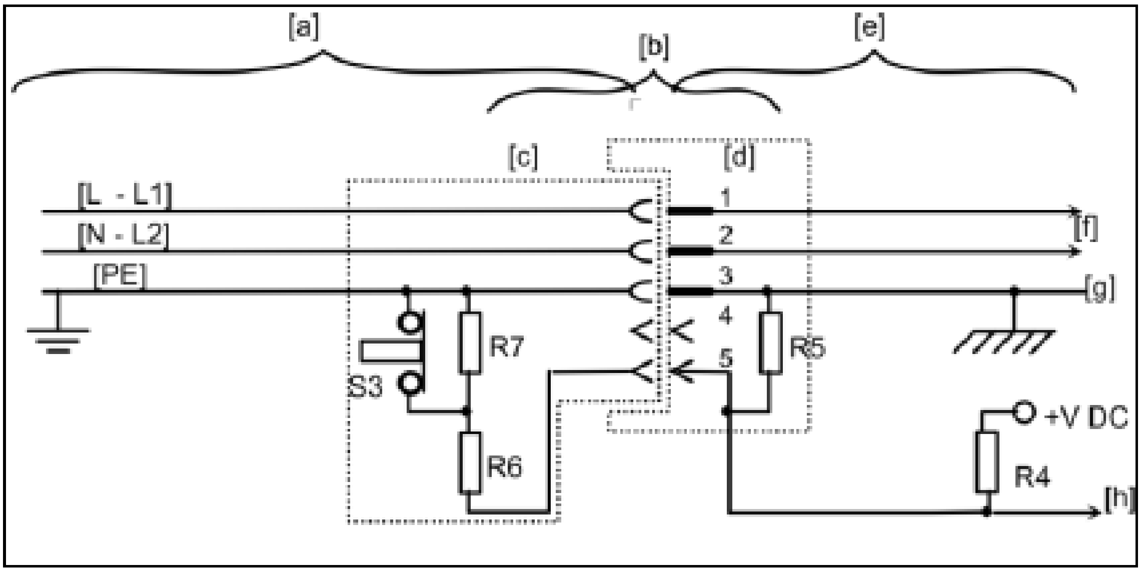
(*Clause* 11.2)

PROXIMITY DETECTION AND CABLE CURRENT CODING CIRCUITS FOR THE BASIC INTERFACE

B-1 CIRCUIT DIAGRAM FOR VEHICLE COUPLERS USING AN AUXILIARY SWITCH ASSOCIATED WITH THE PROXIMITY DETECTION CONTACT

The vehicle couplers using the proximity contact with an auxiliary switch and without current capability coding of the cable assembly shall use the circuit diagram as indicated in Fig. B-1 and Table B-1.

NOTE — The function of "proximity detection contact" is given in **3.3.5**.



Key	
a cable assembly	f a.c. supply to the vehicle
b vehicle coupler	g vehicle chassis connection
c vehicle connector	h to proximity detection circuit
d vehicle inlet	S3 auxiliary switch
e circuit on the vehicle	R4, R5, R6,R7 defined in Table B-1.

NOTES

1 The control pilot function is not indicated in this drawing.

2 The switch S3 can be used for prevention of unintentional live disconnect.

3 This scheme is used for the Type 1 vehicle connector as defined in IEC 62196-2.

FIG. B-1 EQUIVALENT CIRCUIT DIAGRAM FOR PROXIMITY FUNCTION USING AN AUXILIARY SWITCH AND NO CURRENT CODING

Table B-1 Component Values Proximity Circuit without Current Coding

	Value	Tolerance
R4 a	330 Ω	± 10 percent
R5 a	2 700 Ω	± 10 percent
R6	150 Ω	± 10 percent ≥ 0.5 W
R7	330 Ω	± 10 percent ≥ 0.5 W
+ +V cdc,[a),c)]	5V	± 5 percent

[a)] These are recommended values.

B-2 CIRCUIT FOR SIMULTANEOUS PROXIMITY DETECTION AND CURRENT CODING

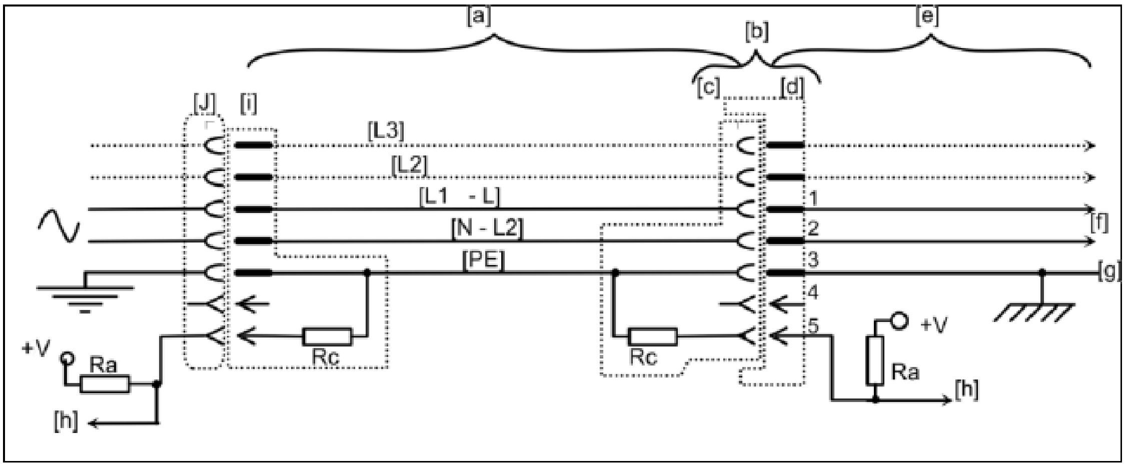
Vehicle connectors and plugs using the proximity contact for simultaneous proximity detection and current capability coding of the cable assembly shall have a resistor electrically connected between the proximity contact and the earthing contact (*see* Fig. B-2) with a value as indicated in Table B-2.

The resistor shall be coded to the maximum current capability of the cable assembly.

The EV supply equipment shall interrupt the current supply if the current capability of the cable is exceeded as detected by the measurement of the Rc, as specified by the values for the recommended interpretation range in Table B-2.

The EV supply equipment shall detect the current coding by measurement of the Rc, as defined in Table B-2 and use the result to set the value of the maximum allowed current, if necessary, according to **6.3.1.6**.

The resistor is also used for proximity detection.



Key	
a cable assembly	g vehicle chassis connection
b vehicle coupler	h to proximity detection circuit
c vehicle connector	j EV socket-outlet
d vehicle inlet	i EV plug
e circuit on the vehicle	Ra, Rc defined in Table B-2.
f a.c. supply to the vehicle	

The control pilot function may be necessary but is not indicated in this drawing.

NOTES

1 This circuit does not use an auxiliary switch.

2 This scheme is used on type 2 and type 3 vehicle connectors and plugs as defined in IEC 62196-2.

Fig. B-2 Equivalent Circuit Diagram for Simultaneous Proximity Detection and Current Coding

Table B-2 Current Coding Resistor for EV Plug and Vehicle Connector

Current Capability of the Cable Assembly	Nominal Resistance of Rc Tolerance ± 3 percent[c)]	Minimum Dissipation Rating of Resistances [a), b)]	Range of Resistance Rc for Interpretation by the EV Supply Equipment [e)]
(A)	(Ω)	(W)	(Ω)
	Error condition [d)] or disconnection of plug		> 4 500
13	1 500	0.5	1 100 – 2 460
20	680	0.5	400 – 936
32	220	1	164 – 308
63 (3-phase) / 70 (1-phase)	100	1	80 – 140
	Error condition [d)]		< 60

[a)] The power dissipation of the resistor caused by the detection circuit shall not exceed the value given above. The value of the pull-up resistor Ra shall be chosen accordingly.

[b)] Resistors used should preferably fail open circuit failure mode. Metal film resistors commonly show acceptable properties for this application. Dissipation ratings are chosen to avoid destruction in the case of a fault to + 12 V supply.

[c)] Tolerances to be maintained over the full useful life and under environmental conditions as specified by the manufacturer.

[d)] EV supply equipment shall not provide power.

[e)] The minimum and maximum values of each range shall be tested. The choice of the resistance value at the transition between current levels is at the discretion of the EV supply equipment designer.

ANNEX C

(*Informative*)

EXAMPLES OF CIRCUIT DIAGRAMS FOR A BASICAND UNIVERSAL VEHICLE COUPLERS

C-1 GENERAL

This Annex gives examples of circuit diagrams for the Mode 1, Mode 2 and Mode 3 charging methods using the basic interface (*see* Fig. C-1 to C-5). It is included to give an overview and an historical record.

An example of Mode 4 charging is presented with the universal vehicle coupler (*see* Fig. C-6).

C-2 CIRCUITS DIAGRAMS FOR MODE 1, MODE 2 AND MODE 3, USING A BASIC SINGLE PHASE VEHICLE COUPLER

Fig C-1, C-2, C-3 and C-4 below show the application of a single phase basic interface fitted with a switch on the proximity circuits.

The auxiliary coupler contact indicated in the figures can be used for unintentional live disconnect avoidance using switch on vehicle connector. For example, for this function, the push button is linked to a mechanical locking device. The depressing S3 unlocks the coupler and opens the circuit. The opening of S3 stops charging operation and contributes to prevention of unintentional live disconnect.

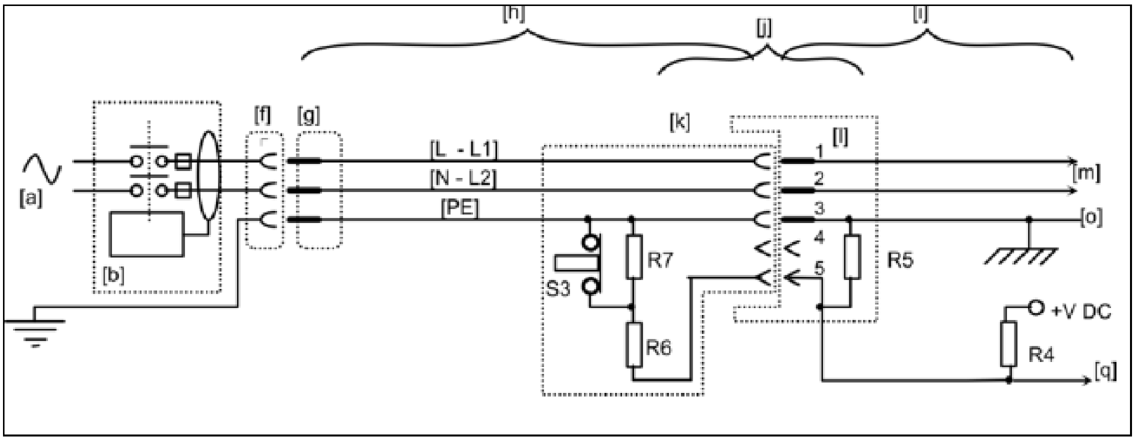
This function can also be achieved using proximity switches or contacts on the vehicle inlet cover or on the locking device.

Fig. C-1, C-2, C-3 and C-4 can also be realized with a connector that lacks a switch provided the switch S3 is not required.

Clause **C-3** shows the application of a three-phase basic interface that is not fitted with a switch on the proximity circuit, used for single and three-phase supply.

Components and functions in the circuit diagrams shown in Fig. C-1 to C-5 are as follows.

The control pilot function controller is located on the a.c. supply network side.

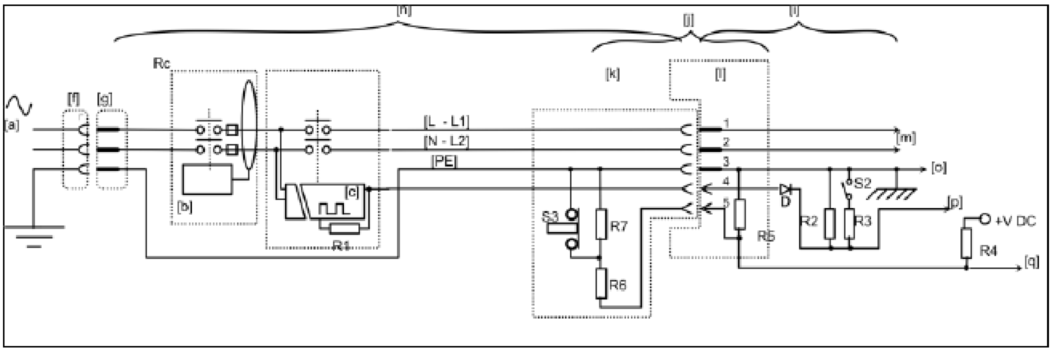


Key

a Supply network
b RCD
c Control circuit for pilot function
f, g Standard plug and socket-outlet
h Cable assembly
i Onboard circuit
j Vehicle coupler
k Vehicle connector
l Vehicle inlet
m To charger and other a.c. loads
o Electric chassis of EV
p To the vehicle pilot function logic circuit
q To the proximity control logic circuit
Pw Control pilot conductor
D,S2,R1,R2,R3 Components for control pilot function. Values are given in Tables A-2 and A-3.
S3,R4,R5,R6,R7 Components for proximity function using an auxiliary switch and no current coding.Values are given in Table B-1.

Contact identification:
1, 2 Phase and neutral contacts
3 Protective earthing contact
4 Control pilot function contact
5 Proximity contact

FIG. C-1 EXAMPLE OF MODE 1 CASE B USING THE PROXIMITY CIRCUIT AS IN B-1



Key

a	Supply network
b	RCD
c	Control circuit for pilot function
d, e	EV socket-outlet, EV plug
f,g	Standard plug and socket-outlet
h	Cable assembly
i	Onboard circuit
j	Vehicle coupler
k	Vehicle connector
l	Vehicle inlet
m	To charger and other a.c. loads
o	Electric chassis of EV
p	To the vehicle pilot function logic circuit
q	To the proximity control logic circuit

Pw Control pilot conductor

D,S2,R1,R2,R3 Components for control pilot function. Values are given in Tables A-2 and A-3.

S3,R4,R5,R6,R7 Components for proximity function using an auxiliary switch and no current coding. Values are given in Table B-1.

Ra,Rc Components for simultaneous proximity detection and current coding. Values are given in Table B-2.

Contact identification:

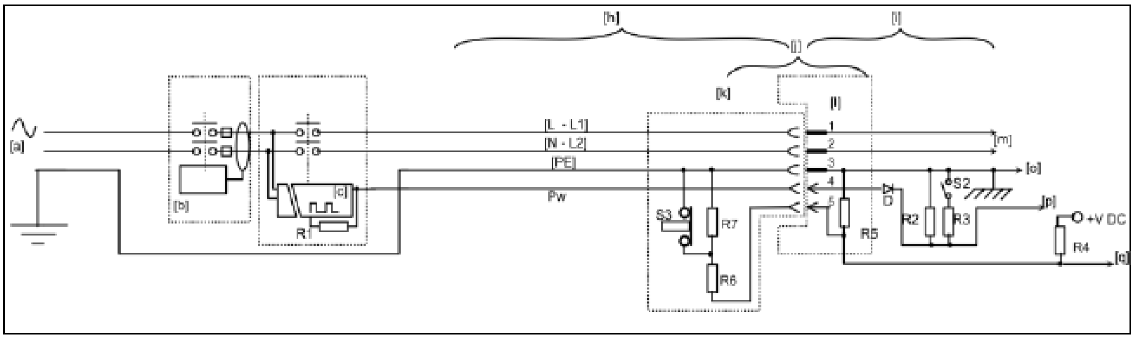
1,2	Phase and neutral contacts
3	Protective earthing contact
4	Control pilot function contact
5	Proximity contact

FIG. C-2 EXAMPLE OF MODE 2 CASE B USING PROXIMITY DETECTION AS IN B-1

This circuit realizes the basic functions described in Annex A. The circuit is normally supplied from an extra low voltage source that is isolated from the a.c. supply network by a transformer and contains a ± 12 V – 1 000 Hz pulse width modulated oscillator that indicates the power available from the socket-outlet.

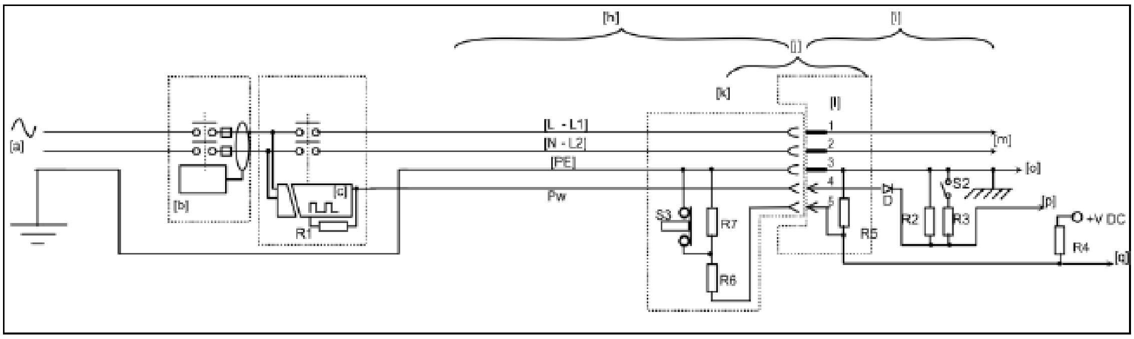
Both Mode 2diagram shown in Fig. C-2 and Mode 3 diagrams shown in Fig. C-3 and C-4 have been drawn with a hard wired control pilot functions as described in Annex A. The basic functions described in Annex A are represented by R1, R2, R3, D and S2 (*see* Fig. A-1). The values indicated in Annex A should be used (*see* Table A-3).

Values of components for the control pilot function are given in Annex A and values for the proximity function are given in Annex B.



Key	
a	Supply network
b	RCD
c	Control circuit for pilot function
h	Cable assembly
i	Onboard circuit
j	Vehicle coupler
k	Vehicle connector
l	Vehicle inlet
m	To charger and other a.c. loads
o	Electric chassis of EV
p	To the vehicle pilot function logic circuit
q	To the proximity control logic circuit
Pw	Control pilot conductor
D,S2,R1,R2,R3	Components for control pilot function. Values are given in Tables A-2 and A-3.
S3,R4,R5,R6,R7	Components for proximity function using an auxiliary switch and no current coding. Values are given in Table B-1.
Contact identification:	
1,2	Phase and neutral contacts
3	Protective earthing contact
4	Control pilot function contact
5	Proximity contact

FIG. C-3 EXAMPLE OF MODE 3 CASE B USING PROXIMITY DETECTION AS IN B-1



Key	
a	Supply network
b	RCD
c	Control circuit for pilot function
d, e	EV socket-outlet, EV plug
h	Cable assembly
i	Onboard circuit
j	Vehicle coupler
k	Vehicle connector
l	Vehicle inlet
m	To charger and other a.c. loads
o	Electric chassis of EV
p	To the vehicle pilot function logic circuit
q	To the proximity control logic circuit
Pw	Control pilot conductor
D,S2,R1,R2,R3	Components for control pilot function. Values are given in Tables A-2 and A-3.
Ra,Rc	Components for simultaneous proximity detection and current coding. Values are given in Table B-2.
Contact identification:	
1,2	Phase and neutral contacts
3	Protective earthing contact
4	Control pilot function contact
5	Proximity contact

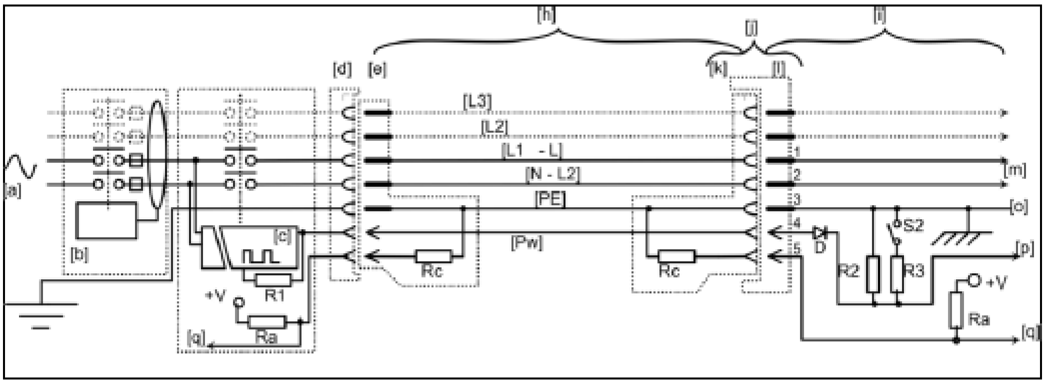
FIG. C-4 EXAMPLE OF MODE 3 CASE C USING PROXIMITY DETECTION AS IN B-1

There is no control pilot function in Mode 1and pin 4 is not compulsory.

C-3 CIRCUITS DIAGRAMS FOR MODE 3, USING A BASIC SINGLE PHASE OR THREE-PHASE ACCESSORY WITHOUT PROXIMITY SWITCH

Fig. C-5 shows a three phase interface accessory that is used for either single phase or three phase supply. The same circuit diagram is also valid for single phase accessories. The current coding function described in **B-2** is indicated. Values of the pull-up resistances are given in Table B-2.

NOTE — Over-current and RCD protection devices [b] can be part of the fixed installation.



Key	
a	Supply network
b	RCD
c	Control circuit for pilot function
d, e	EV socket-outlet, EV plug
h	Cable assembly
i	Onboard circuit
j	Vehicle coupler
k	Vehicle connector
l	Vehicle inlet
m	To charger and other a.c. loads
o	Electric chassis of EV
p	To the vehicle pilot function logic circuit
q	To the proximity control logic circuit
Pw	Control pilot conductor
D,S2,R1,R2,R3	Components for control pilot function. Values are given in Tables A-2 and A-3.
Ra,Rc	Components for simultaneous proximity detection and current coding. Values are given in Table B-2.
Contact identification:	
1,2	Phase and neutral contacts
3	Protective earthing contact
4	Control pilot function contact
5	Proximity contact

FIG. C-5 EXAMPLE OF MODE 3 CASE B USING PROXIMITY DETECTION AS IN B-2
(WITHOUT PROXIMITY PUSH BUTTON SWITCH S3)

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